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ABSTRACT

Summarized in this report are all environmental research projects sponsored by the American Petroleum Institute (API). Included are: (1) status reports on all current projects, (2) published reports on completed projects, together with abstracts of findings, and (3) an organization chart of the Committee for Air and Water Conservation and its various subcommittees, with listings of committee memberships. Committees reporting on current projects are: Health and Biological Research, Engineering and Technical Research, Air Pollution Research Advisory, Wildlife Conservation Liaison, and Division of Refining. Each of the 82 accounts outlines the project name and number, objectives, contractor, and status. Following this abstracts of 79 completed projects, with the name and number of their published report, are compiled. Miscellaneous API environmental reports, medical research reports, and air quality monograph series are also listed and annotated. (BL)

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Environmental Research
A Status Report

A STAFF PAPER

BY THE

COMMITTEE FOR AIR AND WATER CONSERVATION

AND THE

COMMITTEE ON PUBLIC AFFAIRS

OF THE

AMERICAN PETROLEUM INSTITUTE

JANUARY 1972

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Environmental Research

A Status Report

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are available on request from:
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I. INTRODUCTION

This report summarizes all environmental research projects sponsored by the American Petroleum Institute (API). Included are (1) status reports on all current projects; (2) published reports on completed projects, together with abstracts of findings; and (3) an organization chart of the Committee for Air and Water Conservation and its various subcommittees, with listings of committee memberships.

HISTORICAL HIGHLIGHTS

The petroleum industry's concern for the environment is not new. The API's organized efforts to deal with pollution problems go back some 45 years -- to 1927 when the Committee on Refinery Environmental Control (originally called the Committee on Disposal of Refinery Wastes) was established. As its name implies, this group has been concerned with pollution control problems and practices at refineries. Its most important single achievement has been the development and continuing revision of the Manual on Disposal of Refinery Wastes. The manual represents the current state of control technology and deals with air, water, and solid wastes.

At the end of World War II, a second committee was formed within the API Division of Refining to handle other air and water pollution problems. This committee concerned itself with control of pollution resulting from petroleum industry operations and from the use of petroleum products. It sponsored a program of research that from the mid-fifties to the mid-sixties cost more than $2 million.

A third API committee, the Central Committee on Medicine and Health, long concerned itself with aspects of the air pollution problem within its field of interest.

In 1964, still another committee was created to provide a connecting link between the three committees named above and other API components, including the Committee on Public Affairs, which were also involved in activities related to air and water conservation. Its members included representatives from all appropriate segments of the Institute, plus liaison members from other oil industry associations.

COMMITTEE FOR AIR AND WATER CONSERVATION

Early in 1965, recognizing society's steadily growing concern for the quality of our environment, the API Board of Directors named a special ad hoc committee to study all of the Institute's conservation efforts and to make recommendations for streamlining and accelerating those efforts.

The committee, chaired by the late J. C. Ducommun (Standard Oil Company of Indiana), recommended both a series of projects for consideration and the creation of a permanent committee that would have major status within the API. The Ducommun Committee recommendations were approved by the Board in November 1965 and the Committee for Air and Water Conservation (CAWC) was born. For its first year, CAWC was budgeted at almost $2 million for conservation research expenditures. Each year since 1969, CAWC has been budgeted at over $3 million.

CAWC consists of representatives from 20 API member companies -- men chosen for their experience in research, refining, marketing, transportation, production, medicine, and public affairs. Other major oil industry associations also send liaison representatives to CAWC meetings.

Working under CAWC are two committees directly responsible for carrying out the research program. These are the Engineering and Technical Research Committee (E&TRC) and the Health and Biological Research Committee (H&BRC). E&TRC is made up of industry representatives who have important air and water conservation responsibilities within their respective companies. H&BRC consists primarily of oil company physicians who have expertise in biology and related fields.

AIR POLLUTION RESEARCH ADVISORY COMMITTEE OF THE COORDINATING RESEARCH COUNCIL

The Coordinating Research Council (CRC) represents the outgrowth of almost 50 years of mutual endeavor between the automotive and petroleum industries to improve vehicle equipment, fuels, and lubricants. CRC efforts have contributed to significant advances in technology designed to reduce atmospheric pollution caused by vehicle emissions.

In the Fall of 1967, the Air Pollution Research Advisory Committee (APRAC) was formed within the Coordinating Research Council to launch a major program of research on automotive air pollution. APRAC is composed of technical and medical experts from the petroleum and automotive industries and from the U. S. Environmental Protection Agency (EPA).

Funding for APRAC is shared equally between the Automobile Manufacturers Association and the American Petroleum Institute. On a selective basis, EPA contributes financial support to a majority of the projects and shares in the direction of all projects. The research is carried out under contracts with various universities, medical schools, government laboratories, and private research organizations.

The purpose of the APRAC program is not to develop automotive hardware or special petroleum products, but rather to provide basic information on the nature and effects of vehicle air pollution. The program covers subjects of mutual interest to industry and to the government and is divided into three main areas of research:

- Engineering projects which explore the interactions between petroleum products and the automotive equipment in which the products are used (CAPE Projects).
- Atmospheric projects aimed at explaining pollutant behavior in the atmosphere (CAPA Projects).
- Medical projects to determine the effect of automotive emissions upon health (CAPM Projects).

The data acquired from these investigations are expected to provide industry with the technical information needed to achieve further reduction of emissions through the development of improved equipment and petroleum products. The data are also expected to assist the government in establishing air quality standards and emission control requirements.

WILDLIFE CONSERVATION LIAISON COMMITTEE

API's Wildlife Conservation Liaison Committee came into being in 1960 with a mandate to establish and maintain liaison with national conservation leaders in an effort to resolve major environmental problems of mutual concern. The issues and activities that have been freely and frankly discussed in the past have included: leasing and drilling for oil and gas on public lands, particularly in wilderness and wildlife areas; air and water pollution and land conservation; billboards on highway systems and highway beautification; marine drilling operations; the use of pesticides and insecticides; operation of the Bureau of Mines; the Alaska pipeline; the Big Cypress Swamp in Florida; and the need for a long-range national energy and fuels policy.

In addition to its liaison work with conservation organizations, the Committee also works with the Department of the Interior and other agencies and organizations on conservation matters. Annually, it has a top-level meeting with the Secretary of Interior and his staff and other conservation leaders. Through these meetings, the Committee seeks constantly to keep government and conservation organizations informed about what the industry is doing in the field of environmental management and pollution control.

The Committee also sponsors two national scholarship programs, one with the National Wildlife Federation, the other with the Wildlife Management Institute. Although the programs were just initiated, two PhD. projects are now in progress. Matching grants are made to the organizations from a fund approved by API in 1970.

II. STATUS OF CURRENT PROJECTS

HEALTH AND BIOLOGICAL RESEARCH COMMITTEE

PROJECT L-1 -- SEVEN-CITIES STUDY OF AIR AND POPULATION LEAD LEVELS

OBJECTIVE: To determine the characteristic lead levels of air and people living in and around seven cities (Cincinnati, Philadelphia, Los Angeles, Houston, Chicago, New York, and Washington, D. C.), in addition to a control city (Los Alamos); to evaluate these levels in terms of the present knowledge of lead toxicity; and to determine whether changes in ambient air lead levels are associated with changes in human blood lead levels.

CONTRACTOR: Kettering Laboratory, Department of Environmental Health, College of Medicine, University of Cincinnati.

STATUS: In progress.

All of the field work has been completed. Analysis of the samples is nearing completion, and the data are being processed. Although statistical evaluation of the data has not been completed, there does not appear to be any correlation between atmospheric lead levels and the lead levels in the blood of the exposed populations.

A preliminary report on the entire study is expected in January 1972.

PROJECT L-5 -- HIGHWAY PROFILE STUDY: RLEATIONSHIP OF LEAD LEVELS IN AMBIENT AIR AND BLOOD LEAD LEVELS IN EXPOSED HUMANS

OBJECTIVE: To determine whether a relationship exists between highway traffic, lead levels of ambient air in and around homes located at selected distances from the highway, and blood lead levels of the people living in these homes.

CONTRACTOR: Department of Plant Biology, College of Agriculture and Environmental Science, Rutgers -- The State University (N. J.).

STATUS: In progress.

Work on Phase III of the Highway Profile Study has been completed, and the final report is being prepared. Status reports on Phase I, entitled "Atmospheric Lead: Its Relationship to Traffic Volume and Proximity to Highways," and Phase II, entitled "Lead in Soils and Plants: Its Relationship to Traffic Volume and Proximity to Highways," were received in 1970.

PROJECT L-14 -- ALBANY LEAD STUDY

OBJECTIVE: To determine whether the inhalation of a certain level of lead particulates by man produces a detectable adverse effect in the body.

CONTRACTOR: Institute of Experimental Pathology and Toxicology, Albany Medical College of Union University, New York.

STATUS: In progress.

The animal study and the first phase of the human study have been completed. Animals were exposed to 20 micrograms of lead per cubic meter of air, 22 hours a day, for 12 months, and humans to 10 micrograms of lead per cubic meter of air, 22 hours a day, for approximately 5 months. At the present state of data analysis, the only observation considered significant in either study is an increase, followed by a plateauing, of blood lead levels.

In the second phase of the human study, men will be exposed to 5 micrograms of lead per cubic meter of air. The start of the second phase has been delayed in order to give the contractor time to resolve questions that have arisen concerning the analysis of exposure concentrations.

PROJECT L-15 -- EPIDEMIOLOGY OF LEAD POISONING IN FARM ANIMALS

OBJECTIVE: To study the epidemiology of lead poisoning in cattle, including episodes of suspected lead poisoning compiled from records over a five-year period -- their history, clinical signs, postmortem findings, chemical analyses of animal tissues, and possible sources of poisoning. Current episodes studied include field trips by the investigator.

CONTRACTOR: Veterinary Diagnostic Laboratory, Iowa State University.

STATUS: Completed.

The final report on lead poisoning in cattle, entitled "Epidemiology of Lead Poisoning in Cattle," was published in the Iowa State University Veterinarian, No. 3, p. 112, 1970. The main contributing factor to lead poisoning in cattle was found to be poor farm management. In 63 episodes studied, lead poisoning was attributed to paint in 29 per cent of the cases, oil in 25 per cent, junk piles in 11 percent, grease in 6 per cent, batteries in 5 per cent, and "unknown sources" in 24 per cent.

PROJECT S-8 -- THE CHICAGO AIR POLLUTION STUDY

OBJECTIVE: To determine whether a dose-effect relationship exists between the level of air pollution and morbidity in patients with chronic bronchopulmonary disease. To collect morbidity information from patients enlisted from the Chicago Chronic Bronchopulmonary Disease Registry. To collect air pollution data in the form of a daily personal pollution index based upon the patient's travels throughout the city and upon the level of SO_2 in the various areas of the city as determined from data collected by the Chicago Air Pollution Telemetering System.

CONTRACTOR: Chicago Health Research Foundation.

STATUS: In progress.

The final report is being prepared.

PROJECT S-15 -- AN INVESTIGATION OF THE EFFECTS OF SULFUR DIOXIDE ON HUMAN SUBJECTS

OBJECTIVE: To investigate and quantify the effects of exposure to low levels of SO_2 (with and without particulate contaminants) upon healthy and ill human subjects. To establish a maximum safe concentration-time exposure level for SO_2 in the atmosphere. To determine whether or not human subjects suffering from chronic pulmonary, cardiovascular, or metabolic diseases are more sensitive than healty individuals to SO_2 (with and without particulates) in the atmosphere.

CONTRACTOR: The Ohio State University Research Foundation.

STATUS: In progress.

Groups of healthy humans presently are being exposed to 0, 0.3, 1, and 3 ppm of SO_2 in filtered air for 5-day periods. On the basis of cursory analysis of data thus far accumulated, 1 ppm appears to be a probable no-effect level. Studies on the reversibility of pulmonary function effects observed at 3 ppm are being performed. A final report on this work will be issued in January 1972. Similar studies on the exposure of SO_2 to minimally ill subjects are planned for 1972.

PROJECT BR-11 -- TRACE METALS IN URBAN AEROSOLS

OBJECTIVE: To determine long-term trends of trace metal concentrations in urban aerosols due to changing fuel patterns. To analyze beryllium, chromium, nickel, manganese, zinc, and organic materials in seasonal composite samples.

1. To study particulate air pollution in New York City with respect to the following: (a) particle size distribution; (b) concentrations of the selected trace metals in relation to particle size.

2. To determine whether there are correlations between the data obtained from Point 1 and the concentrations of the same trace metals in certain human tissues. Tissue analyses will be performed on samples obtained from routine hospital autopsies.

3. To determine whether there are correlations between the data obtained from Point 1 and respiratory function tests of selected patients under study at the NYU Medical Center.

CONTRACTOR: New York University Laboratory of Environmental Medicine.

STATUS: To be initiated.

Investigators will identify seasonal and local meteorological changes which affect source and dispersion. Abatement programs can then utilize the information to develop optimum economic choices for the control of objectionable or hazardous materials.

API is co-sponsoring this project with the Edison Electric Institute and the Consolidated Edison Company.

ENGINEERING AND TECHNICAL RESEARCH COMMITTEE

PROJECT EF-2 -- EXHAUST AEROSOLS

OBJECTIVE: To explore the relationship between fuel composition and aerosol production in motor vehicles.

CONTRACTOR: Battelle Memorial Institute.

STATUS: In progress.

The experimental work has been completed. As part of the first year's effort, a literature survey was made and released as a finished report (API Publ. 4017). Three additional reports are now in final stages of preparation for release in early 1972. One report will cover work with pure hydrocarbons in a 200-liter irradiation chamber. A second report will summarize vehicle exhaust studies involving several finished gasolines varying widely in hydrocarbon composition which were run in a 1967 Chevrolet V-8 without exhaust controls. These two reports will be in the nature of reference reports and will receive limited circulation. A third report presenting a more general review of the major findings will be prepared for wide distribution under an API publication number.

Data on pure compounds showed that aromatic compounds produce large amounts of photochemical aerosol. Binary hydrocarbon systems with paraffins and olefins greatly inhibited the production of aerosol from aromatic compounds. Because of these interactions, it does not appear possible to apply a simple aerosol reactivity index for individual hydrocarbons to predict aerosol formation from a complex auto exhaust mixture.

In tests with automobile exhaust, it was found that both engine aerosol (that material which is produced in the combustion chamber and which exists as particulate matter after dilution of the exhaust) and exhaust aerosol (that material which is formed from gaseous pollutants by photochemical reactions) contribute to visibility reduction. The quantities of both engine aerosol and exhaust aerosol appear to be influenced by fuel composition, but in different ways. In addition to its direct contribution to light scattering, engine aerosol also was found to influence the photochemical production of exhaust aerosol. Although several test fuels were unleaded, the test engine had lead deposits, and the true effects of lead on aerosol formation could not be determined.

Findings from this study will be helpful in planning the continuing studies on fuel effects under Project EF-8.

PROJECT EF-3 -- EMISSION/VOLATILITY RELATIONSHIPS

OBJECTIVE: To develop a mathematical expression to estimate evaporative emissions for motor fuels covering a wide volatility range.

CONTRACTOR: Scott Research Laboratories, Inc.

STATUS: Completed.

A final report has been prepared and approved by API. The final report is in three volumes: a summary report (API Publ. 4077) which has been sent to all API members and two volumes which document in detail the work conducted. The latter two documents, identified as reference reports, are maintained in the API library.

An SAE paper is scheduled for presentation at the January 1972 meeting of the Society of Automotive Engineers.

This work concluded that a nonlinear expression involving Reid vapor pressure (RVP) and percentage distilled at 160°F in the ASTM D-216 distillation adequately correlates fuel properties with evaporative losses from an average vehicle undergoing typical urban driving conditions when the maximum daily ambient temperature is fixed. The expression developed is:

$$\begin{aligned} W = {} & 2.42(A160) + 1.227\,(T_m) + 11.137(SP) \\ & - 0.286(SP)(T_m) + 0.002(SP)(T_m)^2 \\ & - 120.169 \end{aligned}$$

where

W = Evaporative loss, grams per day per car
A160 = per cent evaporated at 160°F in an ASTM D-216 distillation

T_m = Maximum diurnal temperature of interest, $^{\circ}F$

$$SP = \frac{(RVP)^2}{14.7 - 2(RVP)}$$

$$A = \frac{-48.01}{T_m} + 1.58$$

PROJECT EF-5 -- AROMATICS/VOLATILITY COST RELATIONSHIPS

OBJECTIVE: To obtain a cost estimate for holding the aromatics content of the gasoline pool constant while reducing volatility.

CONTRACTOR: Bonner and Moore Associates, Inc.

STATUS: Completed.

When this study was initiated, lead alkyl was not a factor subject to control. The results of this study indicated that a satisfactory octane number could not be obtained if both aromatic and lead content were subject to control. Since the findings of this study are not applicable to an unleaded fuel, it was recommended by the task force that the Bonner and Moore report receive limited distribution. Accordingly, an API publication number was not assigned to this report.

The Bonner and Moore report (API Publ. 4003), "U. S. Motor Gasoline Economics, Volume 2, Volatility Changes and Olefin Reduction," is the most recent complete publication on volatility prepared by the industry.

PROJECT EF-8 -- GASOLINE COMPOSITION AND PHOTOCHEMICAL SMOG

OBJECTIVE: To determine the effect of gasoline composition on exhaust composition and on the development of photochemical smog. Three photochemical smog manifestations are of principal interest: eye irritation, aerosol formation (visibility reduction), and oxidant formation.

CONTRACTORS: Stanford Research Institute and Battelle Memorial Institute.

STATUS: In progress.

Project EF-8 began at the SRI-Irvine Laboratories in September 1970. By July 1971, the first year's program had been completed. During this period, most of the contractor's efforts were devoted to the development of experimental methodology, although some preliminary gasoline composition evaluations were also carried out. Because of difficulties with the program and the announced closing of the SRI-Irvine Laboratories, the EF-8 Project has now been transferred to Battelle-Columbus, where the remaining phases of the program will be completed.

The work accomplished by SRI-Irvine indicates need for further development on some of the experimental procedures and equipment before a completely satisfactory methodology for this type of research is available. A report detailing the development work done by SRI has been made available to Battelle for information purposes and will be distributed to API member companies in the near future. It includes data on vehicle operating cycles, exhaust gas analysis, exhaust gas sampling and transfer systems, aerosol analysis and characterization, smog chamber operations, and SRI's recommendations for improving marginal equipment and procedures, together with the results obtained from the exploratory gasoline composition evaluations.

The exploratory gasoline composition evaluations conducted by SRI indicate that no substantial differences in photochemical smog manifestations were observed between exhausts from the various test fuels at a hydrocarbon concentration of 15 ppm of carbon. However, at 7.5 ppm of carbon some differences in eye irritation were noted (none with parafinic fuels, slight with other fuels). Visibility reduction was slight with aromatic fuels, but there was no visibility reduction with other fuels. The significance of these low-level differences is not known, and the results should be considered tentative pending further investigation and clarification during the second year of the program.

The first draft of the Stanford Research Institute's studies has been reviewed by the task force overseeing EF-8, and final copies should be available in early 1972.

Negotiations with Battelle have now been settled and the work to complete EF-8 is underway. The first unit to be undertaken by Battelle will be the completion of the work begun by SRI on the development of a satisfactory methodology. Outstanding questions to be resolved include the engine operating cycle, the exhaust sampling and transfer system, and methods of measuring photochemical aerosol. Work will then move to the evaluation of gasoline composition effects and an investigation of the possible modification of these effects by atmospheric trace components. Vehicles incorporating advanced emission control systems will be utilized in the third year of the program.

PROJECT EF-9 -- API LIAISON ON REACTIVITY

OBJECTIVE: To maintain liaison with government and other regulatory groups interested in the Engine Fuels Subcommittee research activities.

CONTRACTOR: None.

STATUS: In progress.

On June 24, 1971, the EF-9 task force met with members of the Environmental Protection Agency located at the National Environmental Research Center. At this meeting the following subjects were discussed:

1. Fuel composition limitations.
2. Importance of fuel particulate matter in the atmosphere.
3. Transfer and handling losses of motor fuels.

From discussions at this meeting, there appears to be little concern over compositional questions such as increased aromaticity. With the possible exception of fuel additive regulations, present government emphasis is on engineering programs rather than fuel-related problems. In the future, the polynuclear aromatic content of fuels and the emissions of such heavy metals as cadmium and zinc in the vehicle exhaust will probably receive attention. Although recognizing them as areas of interest, EPA did not indicate that either the inclusion of aldehydes in auto exhaust regulations or the removal of methane from these regulations would receive attention in the near future.

Considerable attention was directed to the significance of handling losses. The importance of these losses relative to actual vehicular emissions of the post-1975 models was emphasized. The recent report "Recommended Procedures for Estimating Handling and Evaporative Losses," prepared by the EF-1 task force, has been forwarded to the EPA representatives.

The emphasis on fuel particulates of less than 2 microns is a new area of interest and is directly related to atmospheric visibility. As a result of this development, immediate plans for releasing automotive exhaust particulate standards have been deferred. It was indicated that such standards might be issued for 1977 model vehicles.

Regulatory groups in New York City and Denver have also shown interest in the Engine Fuels Subcommittee research activities. Several projects such as EF-2 (on aerosols), the reactivity studies by the EF-8 task force, and the Los Angeles aerometric studies (EF-11) will be discussed more widely with governmental and regulatory groups. During the coming months, the EF-9 task force plans to continue its activities in reviewing with interested groups the studies being pursued by the Engine Fuels Subcommittee.

PROJECT EF-11 -- LOS ANGELES AEROMETRIC ANALYSIS

OBJECTIVE: To determine trends in atmospheric pollutants and to correlate these trends with estimates of the inventory of each pollutant, as well as their environmental effects. To evaluate the efficacy of control regulations and predict the effect of proposed control measures on the atmosphere.

CONTRACTOR: To be selected.

STATUS: To be initiated.

The contract for the analysis of the Los Angeles aerometric data, a joint program of the API and the Los Angeles County Air Pollution Control District, has been approved by the Los Angeles Board of Supervisors and has been signed.

The group is in the process of selecting a contractor to perform the statistical analysis.

In the first year this program will analyze the data from six stations taken over a 15-year period for seven different pollutants (hydrocarbons, carbon monoxide, sulfur dioxide, nitric oxide, total oxides of nitrogen, particulates, and oxidants). The analysis will establish trends in concentration levels for each station and for the Los Angeles Basin average.

The University of Wisconsin has been invited to act as a consultant to the joint program committee in the analysis of the results from the six stations.

PROJECT EF-12 -- ALCOHOL/GASOLINE BLENDS

OBJECTIVE: To review the effect of ethyl alcohol in motor gasoline on emissions, octane quality, engine performance, and the economics involved.

CONTRACTOR: None.

STATUS: Completed.

An extensive survey of the literature was made by the EF-12 task force to determine the effect of ethyl alcohol on motor gasoline performance in the vehicle with respect to power, smoothness of operation, and emission reduction. The water solubility of alcohol/gasoline blends was also considered, along with the possible losses to water phase. Also considered was the economics involved in producing sufficient alcohol for the preparation of a suitable blend, along with the costs compared to those of a conventional fuel.

This report (API Publ. 4082) contains the most recent data on alcohol/gasoline blends and should be a useful reference not only for the petroleum industry, but also for government.

PROJECT EF-13 -- COMPUTER MODEL OF AUTO EMISSIONS

OBJECTIVE: To develop a computer program for estimating vehicle emissions by a defined car population using fuels of known composition.

CONTRACTOR: Scott Research Laboratories.

STATUS: In progress.

Scott Research Laboratories was asked in mid-1970 to develop a computer program for estimating quantity and composition of motor vehicle emissions of any defined car population and gasoline. This was to include hydrocarbons, carbon monoxide, oxides of nitrogen, aldehydes, polynuclear aromatics, and particulates. The study was also intended to provide detailed exhaust hydrocarbon information which could be used to estimate exhaust reactivity. Such a program was desired to permit rapid assessment of the effect of fuel composition and vehicle modifications on emissions and to provide guidance in planning future research into the effects of fuel on vehicle emissions. It was clearly recognized that the proposed program would have many shortcomings due to lack of adequate basic information. However, it was expected that the program would initially be superior to any other methods currently in use for making calculations and that it would be mathematically designed for ready updating as new input data became available.

The basic program, as originally contracted for with Scott, has been completed. A preliminary draft of a user's manual prepared by Scott is being reviewed by the task force members. If the logic on which the program is based is found acceptable, the final user's manual and appropriate card decks should be available to permit interested API members to run the program. In 1971, the EF-13 Task Force recommended that funds be budgeted in 1972 to permit the updating of the computer model by Scott. The Budget Review Committee of the API Committee for Air and Water Conservation recommended this study be deferred until 1973.

PROJECT S-4 -- STACK GAS SULFUR REMOVAL

OBJECTIVE: To evaluate the technology and economics of stack gas sulfur removal processes.

CONTRACTOR: GCA Corporation.

STATUS: In progress.

In 1968, the GCA Corporation was commissioned to complete an engineering study of available processes for removal of sulfur oxides from stack gases. The results of this survey will be found in the API Publication 4009.

Although numerous references have appeared in the literature describing new processes for sulfur oxide removal from stack gases, it has been evident that few if any full-scale operating data are available on these processes. In view of this, no further engineering studies have been made by the members of the task force. On August 4, 1971, a literature review was completed and a report prepared.

Close liaison is being maintained with the Environmental Protection Agency (EPA) on the development of new methods, and it is planned to keep the industry apprised of new developments. Also, a cooperative study with EPA and other groups is being considered for initiation during 1972. The funds approved for the 1972 budget would limit the extent of participation by the API. A cooperative study with two or three other sponsors may be necessary to support any extensive study.

PROJECT S-9 -- SULFUR REACTIONS IN STACK PLUMES

OBJECTIVE: To determine reactions of sulfur oxides in stack plumes from oil-and coal-fired combustion equipment under various conditions.

CONTRACTOR: Battelle Memorial Institute.

STATUS: In progress.

The oil-firing portion of the test program has been completed. Results indicate very little depletion of SO_2 in the stack or plume regions. A definite depletion was observed, however, across the superheater/economizer section. Also, some possible depletion has been observed in the furnace section with the two Venezuelan fuels. Particulate analyses indicate that the major portion of the sulfur oxide depletion can be accounted for by sorption in the ash.

Two coals have been tested with results very similar to those obtained from oil. A test on a third coal has been thwarted because the low ash fusion temperature of this coal led to pressure fluctuations in the system.

Evaluation of the data is continuing and efforts to strike a sulfur balance are being made. It is hoped that a final report can be issued during January, 1972.

PROJECT S-11 -- STUDY OF SULFUR DIOXIDE IN PHOTOCHEMICAL SMOG

OBJECTIVE: To study reactions of sulfur oxides under controlled conditions in the presence of selected hydrocarbons and NO_x.

CONTRACTOR: Battelle Memorial Institute.

STATUS: In progress.

This study was initiated in 1967 as a three-year study. Reports describing the results of the first two years' activities will be found in API Publications 4013, "A Study of Sulfur Dioxide in Photochemical Smog -- First Annual Report -- August 1968," and 4019, "A Study of Sulfur Dioxide in Photochemical Smog II -- Second Annual Report -- August 1969."

Although the experimental work covering the third year was completed in March 1971, the final preparation of the report on this phase of the study has been delayed. The report on the third year, the report summarizing the activities for all three years, and a report on the New York City pilot study are scheduled for release in late 1972. With the release of these reports, the study on reactivity of sulfur dioxide will be completed.

PROJECT S-13 -- SULFUR DIOXIDE ADSOPRTION BY PARTICULATES

OBJECTIVE: To study the sulfur dioxide adsorption characteristics of various particulates.

CONTRACTOR: Department of Environmental Sciences, University of North Carolina, Dr. D. Fraser.

STATUS: Completed.

This study was initiated in 1968 at the University of North Carolina under the direction of Dr. Fraser. A report (API Publ. 4079) entitled "Sulfur Oxide Adsorption by Particulates" has been released.

The primary purpose of this project was to investigate adsorption of sulfur dioxide by a variety of particulate surfaces in the presence of other common gaseous contaminants. In the experimental procedure, measured quantities of $S^{35} O_2$ were introduced in a closed-loop, fluidized bed of particulate matter. Radiation detectors were used to measure the sulfur dioxide remaining in the gas phase on the bed after equilibrium was obtained. The adsorbents used were glass beads, fly ash, graphite, activated carbon, and zeolite cracking catalyst. Other materials added were water vapor, nitrogen dioxide, CO, CO_2, and butene-1.

The pressure of CO and butene-1 was found to increase the adsorption of SO_2 on all surfaces except the glass beads. The adsorption of SO_2 was found to increase as the concentration of SO_2 increased in the gas phase. Adsorption also increased with the surface area of the substrata, and was found to increase in the presence of certain contaminant gases. Attempts to desorb SO_2 from the particle surfaces by heat or by reducing the partial pressure of the sulfur dioxide were unsuccessful.

Data obtained during this investigation indicated that either chemisorption or chemical reactions are taking place on the particle surface. There is no evidence that sulfur dioxide retained its molecular identity or was oxidized to sulfur trioxide. These reactions cannot be described as either simple chemical or physical phenomena.

Based on the findings from this study, it was calculated that if a human were to breathe air containing 1 ppm SO_2 with an inert dust loading of 1 milligram per cubic meter, approximately 9 micrograms of SO_2 would be carried to the alevoli of the lungs in a 24-hour period. It is not likely the ingestion of this small amount of SO_2 would have any biological significance.

PROJECT SS-3 -- PARTICULATE EMISSIONS FROM CATALYTIC CRACKING UNITS

OBJECTIVE: To provide information on extent of catalyst losses and effectiveness of various types of recovery equipment.

CONTRACTOR: None.

STATUS: In progress.

Questionnaires were submitted by the task force to all domestic operators of fluid and moving bed catalytic cracking units, requesting information on type and efficiency of catalyst recovery devices over the length of the run.

A review of the survey has uncovered a number of inconsistencies and indicated that additional information is desirable to permit reliable evaluation of catalyst recovery devices. Responding companies were asked to clarify the information submitted and to provide any additional data.

The final results are now being tabulated. An informal industry report should be available in early 1972.

PROJECT SS-4 -- FLUE GAS RECIRCULATION AND COMBUSTION STUDY

OBJECTIVE: To develop air-pollutant emission control systems for oil and gas-fired boilers by application of external flue gas recirculation and/or delayed combustion air addition.

CONTRACTOR: Marshall Industries, Dynamic Science Division.

STATUS: In progress.

The Environmental Protection Agency and the API are jointly sponsoring a three-year project to determine the optimum conditions for operating oil and gas-fired boilers to maintain the NO_x content of the flue gas at the minimum concentration. In this study, both flue gas recirculation and staged combustion will be investigated to determine the optimum conditions.

The contractor is constructing a pilot furnace for use in these studies. The Foster Wheeler Company is responsible for the package boiler to be used in this pilot plant, which should be available in June 1972. It is planned to conduct a series of experiments with a 1% sulfur No. 6 residual fuel oil representative of that marketed on the East Coast.

The experimental work on the fuel oil is scheduled for the second and third year of the project.

PROJECT SS-5 -- FIELD INVESTIGATION OF COMBUSTION EMISSION FACTORS AND THE EFFECT OF COMBUSTION PARAMETERS THEREON

OBJECTIVE: To complete the field study initiated in 1971 to obtain realistic emission factors from residential and commercial space heating combustion equipment, and to determine the effectiveness of known combustion modification techniques to control emissions from such equipment.

CONTRACTOR: Battelle Memorial Institute, Columbus Laboratories.

STATUS: Phase I completed; Phase II in progress.

Test work has been completed on the 1971 Field Investigation of Emissions from Fuel Oil Combustion for Space Heating (Phase I). The final report has been approved for publication and should be available for distribution in January, 1972.

With the release of this report, Phase I of a two-phase program will have been completed. Negotiations are underway with EPA on a contract for a Phase II program, the cost of which is to be shared equally by EPA and API. Pending issuance of this contract, Phase II work has been initiated by Battelle under an API letter of authorization.

Although useful data on particulate and gaseous emission factors were secured on oil-fired residential and commercial units in Phase I, the next phase of this study will supply the necessary additional information to confirm these factors and supply operating data. Emission data on gas-fired units are also being obtained for comparison purposes.

Also to be investigated in depth will be the effects of operating variables and combustion modification on air pollutant emissions from residential and commercial heating equipment. Representative populations of burners, furnaces, and boilers will be chosen statistically according to size distribution, design type, fuel type, age, flexibility for testing and/or other important variables which may be identified. Field and commercial laboratory units will both be incorporated in the testing program.

The emphasis in Phase II will be divided about equally between the domestic and commercial studies.

PROJECT SS-8 -- PETROLEUM INDUSTRY PROCESS PERFORMANCE STANDARDS

OBJECTIVE: To assist the Environmental Protection Agency in the development of meaningful performance standards for the petroleum industry.

CONTRACTOR: None.

STATUS: In progress.

On August 17, 1971, the standards of performance for new and modified stationary sources were published in the Federal Register for five categories: fossil-fired generators, incinerators, cement plants, nitric acid plants, and sulfuric acid plants. On that date, an API task force met with Environmental Protection Agency (EPA) representatives to review the development of realistic performance standards scheduled for release in December 1971.

It became evident the EPA representatives were not familiar with the complexity of the petroleum industry operations and it was recommended a second conference be held on September 28, 1971. At that conference, the current status of the various industry processes was reviewed. Both EPA and the industry task force outlined approaches for the development of these standards.

According to the EPA, visible emissions of process heaters and boilers will be included in the standards. In the case of the catalytic cracking operations, the particulate and CO content of the emissions will be used as the criteria for development of the standards. Also, hydrocarbon emissions from tank car and tank truck loading, as well as storage, would be subject to regulation. The hydrogen sulfide content of the refinery process gas stream is another standard which needs to be monitored and retained in certain limits.

In view of the complexity of the operations, representatives of the industry were invited to assist in the development of these standards by serving on an advisory committee. Nominations for this advisory committee have been submitted for consideration.

PROJECT BR-12 -- PROJECT THRESHOLD

OBJECTIVE: To determine the reproducibility and repeatability for standard methods for ambient air and stationary emissions.

CONTRACTOR: To be selected.

STATUS: To be initiated.

AD HOC -- LUBE OIL EMISSIONS

OBJECTIVE: To develop information on motor oil's contribution to exhaust emissions. An information report with recommendations was submitted at the 1971 fall meeting of the Engine Fuels Subcommittee.

CONTRACTOR: None.

STATUS: In progress.

The task force members are conducting a literature search. The subject was submitted to APRAC for its consideration as an extension of an existing project. This area of study was considered in the early days of APRAC as a potential research project and is now being reconsidered by their Engineering and Advisory Group.

The first meeting of the task force as a whole was scheduled for September 19 , 1971. Subsequent meetings will be scheduled as necessary.

PROJECT OS-2 and OS-3 -- MATHEMATICAL MODELING AND ENVIRONMENTAL TESTING OF CONTAINMENT BOOMS

OBJECTIVE: To develop a mathematical model to explain the spread of uncontained oil on water; to develop a mathematical model describing the forces acting on containment booms deployed in the sea; to validate this treatment by means of model tests in a wave tank; to validate both the mathematical models and wave tank tests by model and full-scale tests at sea under severe environmental conditions.

CONTRACTOR: Poseidon Scientific Corporation.

STATUS: In progress.

A mathematical relationship has been developed to explain the spread of uncontained oil on water. This relationship considers the environmental factors such as wind and current, as well as oil characteristics.

Typical containment booms have been characterized in terms of design features such as the nature of the physical barrier, means of flotation, etc. A computer-based mathematical model has been constructed to analyze the forces and stresses acting on booms when deployed in the sea, with emphasis being placed on wind, wave, and current, permitting a determination of the impact of these forces on deployment attitdue, mechanical integrity, etc. The effect of oil impinging on the physical barrier has not yet been incorporated into the model.

A series of tests of scale models of typical booms in wave tanks has been completed, both with and without oil. Analysis of experimental results and revision of the mathematical development are in progress.

The phase of OS-3 requiring tests at sea of one-third or one-half scale and full-scale booms remains to be accomplished.

PROJECT OS-5 -- SEA DRAGON

OBJECTIVE: To demonstrate the capability of currently available equipment to contain, sweep, remove, separate, and store spilled oil under high sea state conditions.

CONTRACTOR: Garrett Corp. AiResearch Division.

STATUS: Completed.

All work has been completed, a final report received, and a film of the sea tests of the "Sea Dragon" concept issued.

An open ocean oil spill recovery system was tested in the seas off Santa Barbara, California. This system included a 45-ft. skimming barge developed and built by AiResearch for the Federal Water Quality Administration, now a part of the Environmental Protection Agency, and containing a 500-gpm centrifuge for separation of oil/water emulsions.

Two booms -- a heavy duty boom and an inflatable boom -- that were commercially available prior to the start of the Sea Dragon program, were procured, tested, and evaluated. A third boom -- a water spray boom -- was developed during the program by the Pacific Northwest Laboratories Division of Battelle Memorial Institute, and was also tested at sea.

A rubberized fabric storage vessel of 140,000-gal. capacity, which was loaned by the U. S. Coast Guard, was employed as the oil storage vessel to allow demonstration of a complete recovery system.

Twenty days of sea testing over a 4-month period, much of it in natural oil slicks from underwater seeps, allowed investigation of the ability of the system to sweep at various rates and sea conditions. Efficiency numbers were measured by spilling fresh crude oil on the ocean in front of the system and comparing the amount of oil recovered to the amount dumped. At 1.2 knots and calm sea conditions, the skimmer subsystem displayed an efficiency of 90 per cent, dropping to 75 per cent at 2.3 knots and sea conditions of light winds and one foot chop. Under conditions ranging from flat calm to three-foot waves and 18-knot winds, boom efficienies ranged from a visually estimated 95 per cent down to 13 per cent.

The need for further development in this field was clearly demonstrated.

Copies of the final report on this project, entitled "Oil Spill Containment and Removal System: A Feasibility Study," is available on loan from the API library, Washington, D. C.

PROJECT OS-5A -- DEVELOPMENT AND DEMONSTRATION OF NEW DEVICES FOR REMOVAL AND SEPARATION OF SPILLED OIL

OBJECTIVE: To demonstrate the capabilities of Reynolds Submarine's skimmer and voraxial separator featuring an open-center pump and Medusa modules to remove and separate spilled oil under high-sea conditions.

CONTRACTOR: Reynolds Submarine Services Corporation.

STATUS: In progress.

Construction of the Medusa module has progressed rapidly and is almost complete. Problems encountered by the contractor with respect to the open-center pump component have resulted in a substantial delay in design and construction of the skimmer and voraxial separator units. Attempts are being made to overcome these difficulties. An alternate pump system proposed by the contractor was unacceptable to API. Inability of the contractor to construct and test all units essentially as required by the contractural work program may necessitate termination of this project.

PROJECT OS-6 -- OIL SPILL TREATING AGENTS -- A COMPENDIUM

OBJECTIVE: To revise the compendium published in 1970 by updating and supplementing information contained therein.

CONTRACTOR: Battelle-Northwest.

STATUS: In progress.

The Compendium on Oil Spill Treating Agents was originally published in May, 1970. The contractor has kept his files current by using funds provided by API in 1970 under a contract extension. A revised compendium will be issued in late 1971. In 1972 and thereafter, revisions will be made by replacing out-of-date sheets with new data sheets.

PROJECT OS-7/8 -- OIL SPILL TREATING AGENTS -- DEVELOPMENT OF LABORATORY METHODS FOR MEASURING DISPERSANT EFFICIENCY AND TOXICITY

OBJECTIVE: To establish standard evaluation and test procedures for oil spills cleanup treating agents, including methods for evaluating both effective limitations and toxicity.

CONTRACTOR: Battelle-Northwest.

STATUS: In progress.

A one-year contract was issued July 1, 1971. A regional survey of test indicator biota potentially vulnerable to oil and oil spill treating agents has been completed. Uptake of carbon-14 labeled carbonate has proved to be a reliable test of the effects of oil dispersants on algae. Experiments to evaluate the effects of dispersed oil on amphipod behavior are underway. The development of testing procedures for sublethal effects has just begun.

Typical crudes have been defined and acquired for the development of a laboratory test method to measure the effectiveness of dispersants. Pilot work with one test method revealed deficiencies in reproducibility. An improved test method has been developed in accordance with API recommendations, and a new test program scheduled.

PROJECT OS-11 -- MANAGEMENT CONSULTANT

OBJECTIVE: The API has retained the Pace Company to serve as a management consultant on several oil spills projects.

CONTRACTOR: The Pace Company.

STATUS: In progress.

The Pace Company's representative, Dr. Stanley Pier, continues to serve the Oil Spill Cleanup Subcommittee in a number of areas on various projects.

In general, the modus operandi is at the request of a given task force, with the approval of the Subcommittee Chairman, on which informal state-of-the-art in a given area is investigated. Following this report to the task force, a decision is made regarding the advisability of proceeding with a request for proposals (RFP). In conjunction with the task force or panel, an RFP is written by the Pace Company and sent to preselected potential bidders. Pace receives the proposals, distributes these to appropriate task force or panel personnel, and arranges and conducts a bidders' conference with the task force or panel. Upon selection of the contractor, the Pace Company assists API staff and industry lawyers and patent attorneys in negotiating the contract.

During the course of the contract, the Pace Company monitors the contract work as requested and represents the task force or panel as required. As the contract draws to a close, the Pace Company may review and distribute draft copies of the final report to the appropriate task force and/or panel and negotiate changes as the task force or panel directs, to lead to successful completion of the contract and issuance of the final report.

The Pace Company, in addition, responds to unsolicited proposals, assuring that proper API disclosure of information forms are executed, makes preliminary review of such proposals, and brings to the attention of the proper API group those unsolicited proposals which seem to have some degree of merit.

The Pace Company, on request, performs numerous miscellaneous duties for the Subcommittee, such as draft preparation of speeches and letter of inquiry responses, and disseminates information throughout the Subcommittee, its task forces and panels on oil spill containment and pick-up which has come to their attention through contacts with private organizations and federal agencies.

PROJECT OS-12 -- OILED WILDFOWL REHABILITATION

OBJECTIVE: To develop a primer on treating oil-soaked birds, to study methods of waterfowl rehabilitation, to survey the state of the art, and to compile a bibliography on the subject.

CONTRACTOR: Philip B. Stanton, Wildlife Rehabilitation Center, Framingham, Massachusetts.

STATUS: In progress.

A primer, tentatively entitled The Rescue and Rehabilitation of Oil-soaked Birds, is now in the final stages of development and should be available in early 1972. An extensive survey of literature on the rehabilitation of oil-soaked waterfowl is also nearly complete. A monograph on the cleaning of oil-soaked birds has been completed. Work is also continuing on the construction of Mr. Stanton's Wildlife Rehabilitation Center, located in Massachusetts.

PROJECT OS-13 -- API-EPA-USCG JOINT CONFERENCE ON PREVENTION AND CONTROL OF OIL SPILLS

OBJECTIVE: To hold a second conference on the prevention and control of oil spills in Washington, D. C. at the Sheraton Park Hotel on June 15-17, 1971, jointly sponsored by API, the Environmental Protection Agency, and the U. S. Coast Guard.

CONTRACTORS: Courtesy Associates, Hargrove Displays, Inc., and West & Brady, Inc.

STATUS: Completed.

The Conference was held as scheduled. The total registration was 1,178, with 315 from the petroleum industry. The program included 45 papers plus a panel session on cleanup experiences.

The proceedings of the meeting, which included an additional 21 papers, were distributed at the meeting. It is expected that 4,000 copies of the proceedings will be distributed eventually.

The exhibits comprised 72 booths which were rented by 44 companies and organizations. A film festival was included at a theater in the exhibit hall with 11 films being shown on a continuous basis.

The conference included three luncheons at which Dr. Jacques Piccard, Research Oceanographer; Alex McDonell of the Environmental Action Coalition of New York; and Lynton K. Caldwell of the Department of Political Science, Indiana University, were the speakers.

A third conference is planned for March, 1973.

PROJECT OS-14 -- SEMINAR EXPENDITURES

OBJECTIVE: To hold seminars with various governmental agencies during the year similar to the Seminar on Oil Spills Treating Agents held in Washington, D. C. on April 8-9, 1970.

CONTRACTOR: None.

STATUS: In progress.

During the first six months, no seminars were scheduled with government agencies and the task force. At the present time, there are no plans for sponsoring formal seminars, such as the Industry-Government Seminar on Oil Spills Treating Agents, during the remainder of 1971.

PROJECT OS-15 -- LEGAL ASSISTANCE FOR OIL SPILL COOPERATIVE DEVELOPMENT PROGRAM

OBJECTIVE: A lawyer, after a study of present oil spill cooperatives, would assist in organizing other cooperatives and would prepare agreements as required to suit local conditions.

CONTRACTOR: To be selected.

STATUS: In progress.

The task force on response plans and the panel assigned to monitor the OS-15 project selected twenty areas in the U. S. for the development of oil spill cooperatives. Of these areas, Pittsburgh was selected for the development of the first cooperative.

G. A. Gilmore of Marine Management Services has been commissioned to work with the various organizations in the development of a cooperative during the last half of 1971. On the completion of this assignment, a report will be prepared outlining the procedures employed and recommendations made for future applications in other areas.

The task force will continue to study the status of cooperatives and plan programs for future development in other areas. Close liaison is being maintained with the Committee on Public Affairs.

PROJECT OS-16 -- ENVIRONMENTAL TESTING OF CONTAINMENT CONCEPTS

OBJECTIVE: To test and demonstrate advanced devices for containment of oil spilled on the open seas.

CONTRACTOR: To be selected.

STATUS: To be initiated.

Budgeted but inactive in 1971.

PROJECT OS-17 -- SHORELINE RESTORATION

OBJECTIVE: Present methods to restore shorelines polluted by oil spills are inadequate. It is imperative that present methods be evaluated or new methods be devised to cope satisfactorily with this problem. These developments would probably lead to a demonstration project similar to the Sea Dragon concept.

CONTRACTOR: To be selected.

STATUS: Not authorized for implementation at this time. Project being designed, and qualified contractors are being sought.

PROJECT OS-18 -- ABSORBENT RECOVERY

OBJECTIVE: To develop a system to harvest absorbent materials used to pick up oil spilled on the open seas.

CONTRACTOR: Ocean Design and Engineering, Inc.

STATUS: In progress.

Adaptation and preliminary field testing of a marine weed harvester as an absorbent recovery device is progressing according to schedule. A one-third scale model was first constructed and tested to define limitations and indicate necessary modifications of the off-the-shelf weed harvester to adapt it to absorbent recovery. Construction of a full-scale unit has also been completed. Special coatings have been specified for protection from salt water and petroleum. Testing of the full-scale unit is scheduled for early 1972.

PROJECT OS-19 -- TRAINING FILM

OBJECTIVE: To produce a training film designed to illustrate for industry personnel the equipment and techniques employed to cope with oil spill emergencies.

CONTRACTOR: Shell Pipeline Company.

STATUS: In progress.

Shell Pipeline has been selected as the contractor, and the contracting process is under way. The project has a time completion estimate of six months. Work has been initiated under an API letter of authorization.

The film will cover the full range of equipment and techniques used in spill emergencies. Emphasis will be placed on the relatively quiet water environment. Areas to be covered include the deployment and recovery of containment booms, application and harvesting of absorbents and cleaning of contaminated shoreline areas. A broad range of equipment will be shown, avoiding undue emphasis on individual manufacturers or vendors.

PROJECT OS-20A -- EFFECTS AND FATE OF OIL IN THE MARINE ENVIRONMENT

OBJECTIVES: 1. To determine biological effects of oil and dispersed oil on marine organisms. Both short-term and long-term effects are sought on a broad spectrum of the marine ecosystem (i.e. phytoplankton, zooplankton), shellfish and fish.

2. To determine the fate of oil in the sea.

CONTRACTOR: Battelle Memorial Institute, Northwest Research Laboratories (Battelle-Northwest).

STATUS: In progress.

This laboratory program was initiated in July, 1970, under a contract between Battelle-Northwest and Esso Research and Engineering Company. Sponsorship was assumed by API as of January 1, 1971. The basic contract was amended in August, 1971, to extend the time, scope, and cost of the project, which is now to be completed in early 1972.

An interim report was submitted on June 1, 1971. It covers work done on (a) biological effects (acute, chronic "sublethal" toxicity) of chemically treated and untreated oils on "valued" marine organisms and (b) utilization of such oils by bacteria and other microorganisms. Oils studied are two crudes, No. 6 and high-aromatic No. 2.

Considerable progress has recently been made in the program, including resolution of some difficult analytical programs. The bioassay techniques developed in this program and under API project OS-8 represent substantial accomplishments. No hydrocarbon uptake analytical data, a most important project item, are yet available. A major percentage of the test exposure work has yet to be performed before scientifically acceptable conclusions can be reached.

A final report on the utilization of treated and untreated oil by microorganisms is scheduled to be submitted in late 1971.

PROJECT OS-20B -- OIL POLLUTION SURVEY OF THE SOUTHEAST FLORIDA COAST

OBJECTIVE: To ascertain the differences between present southeast Florida coast pollution by oil and that found 13 years ago by J. V. Dennis as described in the API report "Oil Pollution Survey of the United States Atlantic Coast with special reference to Southeast Florida Conditions," May 15, 1959.

CONTRACTOR: J. V. Dennis.

STATUS: In progress.

Under a contract with API, J. V. Dennis initiated a one-year survey in June, 1971, of the extent of oil and tar pollution on selected beaches north of Miami Beach, Florida: West Palm Beach and Highland Beach. Careful selection of areas to be surveyed is mandatory because of the marked effect of local beach cleaning operations which could invalidate the results of the study. Early results indicate that contamination may be lower than noted 13 years ago, but more data are needed before this can be confirmed. An effort is under way to provide analytical services to identify the sources of the oil and tar samples found on the beaches.

PROJECT OS-20C -- CLINICAL STUDIES OF TOXICITY OF OIL IN WATER

OBJECTIVE: To determine (1) the effects of oil on physiologic parameters; (2) how aquatic animals become contaminated with oil which is in solution, adsorbed on particles (sediment), or in the food chain (ingestion of contaminated organisms); (3) the extent and rate of accumulation of oil and the sites of contamination; (4) the retention and turnover of animal tissue containing oil; and (5) the sequential accumulation of oil in larger species via the food chain. Test organisms are to include oysters, clams, marine worms, shrimp, and fish species.

CONTRACTOR: To be selected.

STATUS: To be initiated.

A contractor has been selected for negotiations and initiation of the half-year project is anticipated before the end of 1971.

PROJECT OS-20D -- SURVEY OF SUBLETHAL EFFECTS ON BIOTA OF CHRONIC NATURAL EXPOSURE TO OIL

OBJECTIVE: To determine, at a location subject to long-term chronic oil pollution whether the incidence of growth irregularities and abnormalities in local biota are different from normal.

CONTRACTOR: To be selected.

STATUS: To be initiated.

A contractor has been selected for negotiations and initiation of a one- to two-year project is anticipated before the end of 1971.

PROJECT OS-20E -- MANUAL FOR ENVIRONMENTAL IMPACT ASSESSMENT TEAM

OBJECTIVE: To prepare a comprehensive manual to help in selecting, equipping, and programming the operations of a team of scientists to be available for immediate deployment to assess the environmental effects of major oil spills.

CONTRACTOR: To be selected.

STATUS: To be initiated.

An RFP has been prepared and a bidders' list compiled. Prior to implementing this project, information is being sought on a similar project recently undertaken by EPA, so as to avoid duplication of efforts.

PROJECT OS-20F -- PHYSICAL TRANSPORT OF OIL IN ESTUARIES

OBJECTIVE: To define, in estuaries, the processes by which oil is dispersed throughout the water column and the mechanisms by which the oil is incorporated into the sediments, where it acts as a reservoir for chronic exposure and contamination of benthic organisms.

CONTRACTOR: To be selected.

STATUS: To be initiated.

This project is in the design stage and qualified contractors are being selected.

PROJECT OS-20G -- ANALYTICAL SERVICES ON FATE OF OIL PROGRAM

OBJECTIVE: To provide and operate a central facility for most of the analytical service requirements of the various API projects on the fate and effects of oil. Such services are to include routine and complex analyses, plus necessary analytical method development.

CONTRACTOR: To be selected.

STATUS: To be initiated.

Project requirements are being developed, and qualifications of various potential contractors are being evaluated. Implementation is anticipated in late 1971 or early 1972.

PROJECT OS-21 -- MIGRATION OF OIL IN SOIL

OBJECTIVE: To conduct a feasibility study of means of removing oil that has migrated in the soil.

CONTRACTOR: None.

STATUS: In progress.

A survey was conducted during 1970 to determine the extent of oil seepage incidents in the production, transportation, refining, and marketing activities of the industry. The results of this survey showed a majority of companies supported the preparation of a manual describing the current status of migration of oil in soil and groundwater.

With the concurrence of the Task Force on Response Plans, each member of the panel assigned to this project will prepare a section of the manual. Drafts of several chapters have been finished and the final publication is scheduled for completion early in 1972.

PROJECT OS-22 -- MANUAL ON PREVENTION OF OIL SPILLS

OBJECTIVE: To prepare and print a manual on prevention of oil spills.

CONTRACTOR: None.

STATUS: In progress.

The Oil Spill Prevention Practices pamphlet has gone through several drafts and is nearing final form. Artist sketches and drawings to accompany the text are well in hand. The final draft of the pamphlet was ready for review by API committees in January, 1972.

PROJECT OS-23 -- CONSULTATION ON OIL SPILL INCIDENTS

OBJECTIVE: To assist in a consulting capacity in those cases where oil spills of unknown origin occur.

CONTRACTOR: To be selected.

STATUS: To be initiated.

Budgeted but inactive in 1971.

PROJECT W-3 -- IMPROVED CAPABILITIES OF BIOLOGICAL SYSTEMS TO ASSIMILATE OIL

OBJECTIVE: To (1) determine the tolerance of municipal and industrial biological systems (activated sludge) to various hydrocarbon type compounds, (2) determine the nature of the interference of oily materials with biological treatment, (3) determine the fate of oily materials in the system, (4) study methods of improving the ability of biological systems to assimilate oil, and (5) examine methods of improving pre-treatment for oil removal.

CONTRACTOR: Hydroscience, Inc., Westwood, New Jersey.

STATUS: Completed.

Project complete and final report issued by Environmental Protection Agency: "The Impact of Oil Materials on Activated Sludge Systems." This project was funded as a research grant by the EPA as Project No. 12050 DSH.

It was originally intended that a second phase project be undertaken to demonstrate the findings of this phase and budget funds had been requested to do so. However, the results of W-3 do not support proceeding with a second phase.

PROJECT W-7 -- REFINERY EFFLUENT GUIDELINES

OBJECTIVE: To assist the Environmental Protection Agency in the development of realistic effluent guidelines.

CONTRACTOR: To be selected.

STATUS: To be initiated.

The API 1967 Refinery Effluent Survey data are presently being used by the Environmental Protection Agency (EPA) in defining the interim effluent guidelines for the petroleum industry. A request has been received from the EPA to conduct another survey to update the data in the 1967 report.

It is planned to invite all refineries to participate in a new survey beginning in the latter part of 1971. The questionnaire for this survey is being designed. The advice of all interested persons will be sought prior to finalizing the format. The EPA laboratory at Ada, Oklahoma, will be invited to complete analyses on samples supplied by selected refineries. It is planned to use methods similar to those specified in the Corps of Engineers permit applications.

In addition to the industry survey, a research project planned by a joint EPA-API task force will be formed to determine the waste water treatment efficiency, validate the so-called building block concept, and examine in-plant factors relating to separator effluent quality. The scope of this project will be submitted to both industry and government groups for review and approval for joint sponsorship and funding. If approval is received, it is planned to initiate this study in 1972.

AIR POLLUTION RESEARCH ADVISORY COMMITTEE
COORDINATING RESEARCH COUNCIL

PROJECT CAPE-2-68 -- EFFECTS OF GASOLINE PROPERTIES ON CARBURETOR AND PCV VALVE DETERIORATION

OBJECTIVE: To develop information on the effects of gasoline properties on carburetor and positive crankcase ventilating (PCV) valve performance as they relate to exhaust emissions.

CONTRACTOR: Scott Research Laboratories.

STATUS: In progress.

Scott Research Laboratories was selected to conduct an experimental program to investigate the effects of gasoline additives on carburetor and PCV system performance as they relate to exhaust emissions. Three groups of 16 passenger cars each, or a total of 48 cars, were driven in normal urban and suburban modes of operation with absolute control of vehicle operation, refueling, maintenance, and mileage accumulation rates. Each group of 16 cars was operated on the same base fuel, but two test fuels contained gasoline additives (supplied by CRC) which were added to the base fuel.

Prior to test operations, each vehicle accumulated 3,000 miles before being modified for the fuel additive study. Modifications consisted of a major tune-up, installation of flowed carburetors and PCV valves, and locking idle speed and mixture screws in place after adjustments of the electrical and carburetor parameters.

Measurements of exhaust emissions, PCV valve flow, and idle speed were taken initially in triplicate; single tests were performed at each subsequent 4,000 mile interval. Exhaust emissions were measured with the "hot start" technique in accordance with the 1968 federal procedures and at steady state speeds of 20 mph, 40 mph, and idle.

The first vehicle began accumulating mileage on June 2, 1969, and the last of the 48-car fleet began August 13, 1969. After twelve months of operation, forty-one vehicles had completed

8,000 mile exhaust tests and 14 had been tested at 12,000 miles. An analysis of variance was conducted on 17 emission parameters, PCV valve flow, and idle speed varied significantly between the six car makes in the fleet; however, no single make had consistently the highest or lowest value across the spectrum of the 18 parameters measured. This information was contained in a first year report submitted to CRC by the contractor in April 1970 (API Publ. 4056).

At the end of the twelve months' operation, CRC requested that the testing be terminated at the 12,000 - mile interval. The revised program included:

- Performing duplicate tests at 12,000 miles on all vehicles not previously tested at 12,000 miles.
- Perform a single emission test on all vehicles exceeding 12,000 miles.
- Perform an analysis of variance on the 8,000 - and 12,000 - mile interval data.
- Conduct a regression analysis of ten parameters with those data collected beyond 12,000 miles.

The revised plan was implemented and all mileage accumulation and emission tests were completed by November 1, 1970. All analyses of variance, regression analyses, and multiple comparison tests were completed as of December 1, 1970. In addition, photographs were taken of the carburetor throats and PCV valves for visual evidence of additive effects.

These results are being used to formulate the conclusions, and a final report covering this investigation is being prepared. The final report should be available in early 1972.

PROJECT CAPE-3-68 -- EFFECTS OF GASOLINE PROPERTIES ON EXHAUST EMISSIONS CAUSED BY COMBUSTION-CHAMBER DEPOSITS

OBJECTIVE: To determine the effects of gasoline properties, including additives, on exhaust emissions caused by the effect of combustion-chamber deposits.

CONTRACTOR: None.

STATUS: Completed.

The use of lead compounds, when added to gasolines to enhance their antiknock properties, has resulted in more efficient combustion in high-compression engines, but their use has also caused lead deposits in the combustion chamber. In addition, there is some indication that under certain operating conditions, these deposits may increase hydrocarbon emissions. To assess how lead antiknock compounds in gasolines influence combustion -chamber deposits and equilibrium emission levels, an intensive CRC state-of-the-art review has been made. Data submitted by 18 different companies on pre-emission-controlled cars and 1966 and 1967 models equipped with exhaust emission controls have been analyzed in depth by the CRC project group. Based on this review, it was concluded that cars operated on leaded gasolines have somewhat higher equilibrium hydrocarbon emissions than those operated on unleaded gasolines. However, no effect was noted for either carbon monoxide or oxides of nitrogen. A comprehensive report containing a detailed compilation and analysis of the data transmitted to the CRC group has been completed and is available as CRC Report No. 441.

PROJECT CAPE-4-68 -- FUEL VOLATILITY

OBJECTIVE: To study the interactions of fuel volatility and automotive design as they relate to driveability and total emissions.

CONTRACTOR: Bureau of Mines; Ethyl Corporation.

STATUS: In progress.

Studies have shown that evaporative emissions from gasoline tanks and carburetors can be decreased by lowering volatility. However, such changes in the composition of fuels can cause automobile operating problems. For example, excessive reduction of fuel volatility may lead to obvious difficulties during starting and warmup and, in some cases, significant volatility reduction may cause an increase in exhaust hydrocarbon emissions. Accordingly, the influence of fuel colatility on exhaust emissions, evaporation losses, and vehicle driveability are being studied in two CRC contract activities under CRC Project CAPE-4-68.

Twelve late-model vehicles were tested for emissions by the Bureau of Mines, and were tested for both cold and warmed-up driveability be the Ethyl Corporation. Test gasolines vary over a wide range in both front-end and midrange volatility. Ambient temperatures were varied from 20°F to 95°F.

Emission tests on all 12 test cars have been completed, and the driveability tests have been completed on the first eight cars. The remaining four cars, all 1970 vehicles equipped with California-type evaporation controls, are undergoing driveability testing at Ethyl. The remaining testing at Ethyl has been completed.

Three of the first eight cars tested for driveability showed sufficient fuel effects in the 45°F to 70°F temperature range. These three cars were returned to the manufacturers for minor mechanical modifications to improve driveability on a test fuel with low front-end volatility. The modifications did not change driveability sufficiently to warrant retesting to establish the effect of these mechanical modifications on vehicle emissions, as called for in the original program plan.

The CRC project group has reviewed the test data periodically. However, no conclusions with respect to driveability or emissions as influenced by fuel volatility have yet been reached. The driveability data are being obtained by a new procedure; consequently, no previous data are available for comparison. However, comparison with tests on similar vehicles run in a Coordinating Research Council program in 1969 at Pasco, Washington, show similar behavior. Emission data on the first eight cars tested are quite similar to those previously obtained at the Bureau of Mines on 1968-1969 model cars for an earlier API program.

The review of emission data on the four 1970 model cars is nearing completion, and the final reports for the project should be available by early 1972.

PROJECT CAPE-6-68 -- GASOLINE COMPOSITION AND VEHICLE EXHAUST GAS POLYNUCLEAR AROMATIC CONTENT

OBJECTIVE: To determine the emission rates of polynuclear aromatics and phenols in vehicle exhaust as these rates are influenced by fuel composition, engine operating variables, and exhaust emission control systems.

CONTRACTOR: Esso Research and Engineering Company.

STATUS: In progress.

The second year of the CAPE-6-68 research program at Esso Research and Engineering Company has been completed. By the end of calendar year 1970, a total of 54 tests were completed, of which 18 were first-year tests. The program is expected to continue into a third year.

In 1970, the project continued the 1969 test program with two test vehicles, a 1966 V-8 without emission controls and a 1968 controlled vehicle. Recently, a 1970 controlled vehicle has also been placed in test operation. A vehicle test consists of 7-mode cyclic operation, from a cold start, on a chassis dynamometer, with all of the exhaust, except a sidestream for IR analysis, cooled and filtered through large-scale equipment. Phenols and polynuclear aromatics (PNA) are analyzed quantitatively in washings and extracts from the vehicle muffler, tailpipe, collecting equipment, condensed water, and fiberglass filters. The yields of PNA are based on analyses for benzo(a)pyrene (BaP) and benz(a)anthracene (BaA) and are related to the amount of fuel consumed in the test (about 2 gallons). Fuel variables studied have included lead antiknock (as TEL, at 0 or 3 cc/gallon), PNA already in the fuel, aromatics content (at one-half, and double, the field average), and, in preliminary studies, some additional aspects of fuel composition. Vehicle variables have included the amount and composition of combustion-chamber deposits, the presence of emission control systems, and the effect on PNA rates, from a given vehicle, of small changes in the emission of CO, i.e., in air/fuel ratio.

Emission rates, per gallon of fuel, range from 3 to 149 micrograms of BaP, from 12 to 303 micrograms of BaA, and from 78 to 776 milligrams of phenolics (as phenol).

The PNA emitted by the emission-controlled 1968 vehicle was only 20 to 40 per cent of the emission from the 1966 uncontrolled car in tests providing a wide variety of PNA-emission level. Reductions in CO emission, either by using a controlled vehicle or by random variation in a given vehicle, are accompanied by reductions in PNA emission. In a given vehicle, a change of only 0.1 per cent CO emitted in the cycle test caused a 9 per cent change in PNA emission. Similarly, recent production low-emission vehicles contribute much less to atmospheric PNA than do earlier uncontrolled vehicles. For both newer and older vehicles, the amount and composition of combustion-chamber deposits appear to have a large effect on PNA emission, but further studies are necessary in this complex area.

The effects of fuel composition on PNA are also complex. The presence of PNA, such as BaP, in trace amounts in gasolines results in increased emission of PNA in the exhaust. Increasing PNA in fuel, as BaP, from 0 to 3 ppm increases the PNA emitted by about 20 per cent. Increasing the aromatics content of fuels from 11 or 12 to 46 per cent also results in increased PNA emission, but the emission at the higher aromatics level may range from nearly equal to three times as great as that at the lower level. At either total-aromatics level, other undefined composition factors are involved and cause wide variations in PNA emission. Data in this area are very limited at present; interest centers in the higher-boiling hydrocarbons as likely precursors of PNA emission. The use of TEL in fuel does not apparently have any substantial immediate effect on PNA emission, but the results indicate that its effect on the presence of lead in engine deposits is important.

Phenol emission is largely controlled by fuel aromatics and apparently approaches near-zero levels at zero aromatics; other fuel composition factors have only small effects compared to fuel aromaticity. Vehicle emission controls (1968 vs. 1966) reduce phenols slightly at low fuel-aromatic levels but generally have little effect with high aromatics, and small changes in CO emission apparently do not affect phenols.

PROJECT CAPE-7-68 -- EXHAUST ODOR MEASUREMENT

OBJECTIVE: To develop technical information needed for the identification and measurement of engine exhaust odor.

CONTRACTOR: Illinois Institute of Technology Research Institute; Arthur D. Little, Inc.

STATUS: In progress.

Under the guidance of the project group, two research organizations have performed contract work on exhaust odor, each using a different approach to determine the odor constituents of diesel exhaust. Work at IIT Research Institute since the early part of 1968 was directed toward a detailed study of individual chemical components in diesel exhaust employing dual column, high resolution gas chromatography combined with sensory evaluation of separated peaks and mass spectrometric analysis. Partially as a result of difficulties encountered with application of the mass spectrometric technique to the very small samples employed in the analysis, the program at IITRI was terminated in early 1970. IITRI did demonstrate successfully one system for exhaust odor characterization using capillary gas chromatography columns. (See API Publ. 4044).

Concurrent work at Arthur D. Little, Inc., is concentrating on isolating odorant species in diesel exhaust condensate by a combination of liquid column chromatography and multiple column gas chromatography. The liquid column separation technique isolates classes of compounds and improves the resolution in the gas chromatographic columns. During 1969, the major classes of hydrocarbons associated with an odor characteristic were identified and progress made in analysis of fractions having a "smoky burnt" odor character.

A.D. Little has continued to use the schemes developed for sample identification earlier in the program to more fully determine the chemical composition of all of the important diesel exhaust odors.

Briefly, the sample preparation scheme involves collection of the exhaust by condensation at 0°C. Recently the condensers were sealed to allow sampling at the rate of 10,000 liters of exhaust per hour. The exhaust condensate is then extracted with pentane and chloroform to isolate the odorous organic fraction.

This extract in the odor test room has the same odor quality as the original exhaust. The concentrated organic extract is then separated into three basic working fractions by liquid chromatography.

The fraction eluted with benzene contains the oily-kerosene exhaust odors. This odor complex is then resolved into its individual components by two stages of gas chromatography (silicone and Carbowax columns) for sensory odor characterization and chemical identification via high-resolution mass spectrometry.

The most significant odor species in the oily-kerosene complex have been shown to be due to the indans and tetraline with contributions from the alkyl benzenes. The naphthalenes do not appear to contribute directly to the odor but may have a synergistic effect on perception of the total odor complex.

The smoky-burnt portion of diesel exhaust odor is eluted from the liquid column in chloroform/methanol. Identification of this fraction has been expected by using just the original chloroform extract, thus eliminating sizable interference by non-odorous species. Work on this fraction is nearing completion, and present data suggest that the most important odor contributions are made by the dienones, phenols, benzaldehydes, indanones, tetralones, naphthols, and their hydroxy and methoxy substituted derivatives (see API Publ. 4045, 4061, 4098,5000).

PROJECT CAPE-8-68 -- KINETICS OF OXIDATION AND QUENCHING OF COMBUSTIBLES IN EXHAUST SYSTEMS OF GASOLINE ENGINES

OBJECTIVE: To develop an understanding of the oxidative phenomena of combustibles under temperatures, pressures, compositions, and flow conditions typical of the exhaust gas from gasoline engines.

CONTRACTOR: University of Michigan.

STATUS: In progress.

The University of Michigan has obtained baseline emission data on a Chevrolet 350 CID V-8 engine. Exhaust gas concentrations have been determined for the following: carbon monoxide, carbon dioxide, aldehydes, nitrogen oxides, total hydrocarbons and hydrocarbon class types (paraffins, olefins, and aromatics). A wide range of engine operating conditions was covered. Air/fuel ratio has the largest effect on emissions, although NO increases rapidly beyond 35^o spark advance for a fixed air/fuel ratio. Class-type analyses of the exhaust hydrocarbons showed that the per cent olefins increased from about 20% at the air-fuel ratio of 10 to about 40% at air/fuel ratio of 15, decreasing slightly when the air/fuel ratio was increased to 19. Exhaust paraffins were highest at air/fuel ratio of 10 and reached a minimum at air/fuel ratio of 15. Exhaust aromatics did not vary much with air/fuel ratio. Emission data are now being obtained from this same engine but with reactors installed. In addition to covering the range of engine operating conditions used in the baseline tests, the effect of the amount of injected air will be investigated.

A computer simulation model has been programmed and successfully run. Literature data for kinetic constants were used in these runs. Conversions are very sensitive to temperature, and a substantial fraction of the combustibles are converted in the reactor inlet. A regression program for analyzing the single-cylinder reactor kinetic data has also been programmed and tested and is ready for use.

A single-cylinder two-tank reactor has been fabricated and installed. Tests on the residence time distribution showed modifications were required in the reactor intervals. These have been made, and the reactor is now well-stirred. The analysis of the kinetic data requires this condition be met. Runs to obtain kinetic data will commence shortly. The technology developed to determine the residence time distribution may be useful on the multicylinder engine reactor. A method for determining the full-scale engine reactor residence time distribution may be required, depending on how important this parameter proves to be when the computer simulation model is used to fit full-scale reactor data.

Velocity and temperature profiles are important. An elegant laser schlieren method of determining velocity profiles has been devised and used to measure velocities in a single-cylinder engine exhaust system. This method will be extended to exhaust gas temperature measurements.

Results from the single-cylinder two-tank reactor and velocity and temperature data will be used in the computer model to simulate the full-scale reactor behavior. These results will then be compared with the emission data now being accumulated. Elucidation of the important factors in exhaust reactor performance is the objective of this work. The information will be helpful to those engaged in the design of practical reactors. (See API Publ. 4078).

PROJECT CAPE-10-68 -- TRAFFIC SURVEY FOR DEVELOPMENT OF AVERAGE DRIVING CYCLE

OBJECTIVE: To collect and evaluate information on urban traffic patterns and detailed vehicle modal operating characteristics, and to recommend any additional action needed to provide information for the development of an average driving cycle for use in future emission research programs.

CONTRACTOR: System Development Corporation; Scott Research Laboratories.

STATUS: In progress.

Contract work in this project is being conducted in two phases. The objective of the first phase is to determine basic traffic patterns in six large metropolitan areas (Los Angeles, Houston, Cincinnati, Chicago, Minneapolis/St. Paul and New York). This phase was carried out by System Development Corporation (SDC). All survey data from tacographs installed in owners' cars have been obtained and summary reports have been completed on all six cities (API Publications 4034, 4046, 4084, 4085, 4086, 4087). An overall summary report of the project, which compares the traffic patterns of all six cities, is completed (API Publ. 4088). In addition, SDC reanalyzed telephone survey data, gathered by 3-M Company under a separate contract, of traffic patterns in Los Angeles (CAPE-5-68) (API Publ. 4089). The reanalysis was to provide a comparison of the two survey techniques, using the same data analysis technique. A draft report of this analysis has been prepared by SDC.

The second phase of this project is being conducted by Scott Research Laboratories. The objective of this work is to obtain detailed vehicle modal operating parameter information (speed, acceleration, deceleration, engine intake vacuum, etc.) on test vehicles operating in the traffic patterns delineated by SDC in phase one. The Scott study is being conducted in two parts. The first part involves obtaining vehicle data in Los Angeles; the second part covers the same type of activities in the other five cities surveyed. The decision to conduct all or part of the vehicle test program in the remaining five cities will be made when the overall summary report on the SDC survey is available for review. Scott is progressing with instrumentation acquisition, route selection and preliminary data acquisition in Los Angeles. This work in Los Angeles is now completed. It is anticipated that the final report will be available by January, 1972.

PROJECT CAPE-11-71 -- IMPROVED INSTRUMENTATION FOR DETERMINATION OF EXHAUST GAS NITROGEN OXIDES AND OXYGENATE CONTENT

OBJECTIVE: To develop improved instrumentation for continuous measurement of exhaust gases for nitrogen oxides and oxygenate content on a concentration, mass, and reactivity basis.

CONTRACTOR: Scientific Research Instrument Corporation; U. S. Bureau of Mines.

STATUS: In progress.

In order to develop satisfactory techniques for measuring oxygenates, the CAPE-11-71 project is conducting two studies under contract. The technology of chemical ionization was combined by Scientific Research Instruments Corporation with direct-reading mass spectrometry in the development of a methodology to analyze simultaneously for nine oxygenates in raw auto exhaust. A prototype instrument was built and is being used to first establish laboratory analyses and then field measurements on a chassis dynamometer for formaldehyde, acetaldehyde, acrolein, propionaldehyde, butyraldehyde, crotonaldehyde, valeraldehyde, benzaldehyde, and toluene. Each analysis is presented on its own meter from 0 to 200 ppm. Response time for all measurements is approximately one second.

In the presence of large quantities of hydrocarbons in the exhaust some interference occurs at acrolein and to a lesser extent at crotonaldehyde. At present these oxygenates are read by difference, using a bicarbonate bubbler.

A series of chassis dynamometer tests was recently conducted with the instrument at Scott Research Laboratories. Steady state measurements were made at idle, 30 mph and 50 mph. Comparison samples were taken and measured independently at the DuPont Laboratories. The overall agreement was satisfactory; some losses occurred with formaldehyde because of an inadequate sample inlet system which was different from the one used to obtain the DuPont samples.

Dynamic tests were made with continual recording of each aldehyde with the one-second response time, during the 7-mode California cycle. The results were excellent and most encouraging.

Work is planned to improve the inlet system, to simplify and improve the calibration procedure, and to simplify the instrument controls and ease of readout, including a digital summation of total aldehydes. The established sensitivity, specificity, and linearity show this method will meet the requirements originally set forth. Finally some work will be done to simplify the interferences with some hydrocarbons, especially interference at acrolein.

The immediate objective of the second study being conducted by the Bureau of Mines is to obtain data on relative levels of carbonyl and noncarbonyl oxygenates in exhausts from gasoline engines using simple hydrocarbon fuels. The ultimate objective is to estimate the contribution of noncarbonyls to total oxygenates in gasoline exhaust in order to determine whether analytical methods for noncarbonyl oxygenates are required.

Experimental design for the study called for generating exhaust samples from test fuels using a current model automobile operated in the laboratory under typical city driving conditions.

The developed analytical procedures were applied to exhausts from six single-component and three multi-component hydrocarbon fuels. Fuel hydrocarbons were selected among those typically present in commercial gasolines. Resultant data led to identifying 34 oxygenates that include: aliphatic saturated and unsaturated aldehydes, ketones, and alcohols; aliphatic ethers and esters; nitroalkanes and phenols; aromatic ketones, alcohols, and ethers. In addition to oxygenates, nitriles were also found to be present (see API Publ. 4071).

Future plans are for more work with simplified (multi-component) fuels, with emphasis on the quantitative aspects of the relationship between exhaust oxygenates and fuel compostition.

PROJECT CAPE-12-68 -- TECHNIQUES AND INSTRUMENTATION FOR ANALYSIS OF EXHAUST GASES FOR PARTICULATE MATTER AND POLYNUCLEAR AROMATICS

OBJECTIVE: To develop techniques and instrumentation for the sampling and analysis of exhaust gases for particulate matter and polynuclear aromatic content. Reducing the analytical cost and elapsed analytical time are of prime importance.

CONTRACTOR: Esso Research and Engineering Company; Battelle Memorial Institute.

STATUS: In progress.

Two programs have been active since initiation of contract work early in 1969.

In the first program, the contractor, Esso Research and Engineering Company, has developed an improved method to determine benzo(a)pyrene and benz(a)anthracene in auto exhaust tar, gasoline, and crankcase oil which results in a substantial reduction in analytical cost over previous methods of similar accuracy (API Publ. 4072, 4074). The CAPE-6-68 project group cooperated in the evaluation and reports that the use of the new method, in preference to the thin layer chromotography-radioactive tracer method, results in a saving in analytical costs of $700 to $800 per sample of auto exhaust tar. Based upon initial experience, the cost per sample is about $400 by the new method.

In the new method, a selected polynuclear aromatic (PNA) fraction is prepared by alumina column chromatography. This PNA concentration then is separated by gas chromatography into various fractions. Those fractions which contain B(a)P and B(a)A are trapped and subjected to ultraviolet absorption spectrophotometry to determine specific concentrations. A radioactive tracer currently is used for internal standardization. Attempts to use several non-radioactive, UV-absorbing, pure compounds for internal standards encountered interference with other components of the complex samples. Checks of the analytical accuracy indicate that B(a)P concentrations are similar by either the old or new methods. On the other hand, B(a)A by the new method often is somewhat lower than by the old method. This appears to be due to the presence of a methylbenz(a)anthracene which is separated from B(a)A by the new method. This ability to determine additional specific compounds which may be of interest in biomedical and other air-pollution research is an important feature of the GC-UV method. Continuing work on this project may explore identification of other polynuclear aromatic compounds present in auto exhaust. A method to determine total PNA content of auto exhaust is also being devised and tested.

In the second program initiated by CAPE-12-68, the contractor, Battelle Memorial Institute, has made exploratory studies of the physical and chemical characteristics of the particulates in auto exhaust, with emphasis on those particles with which polynuclear aromatics are associated. APRAC recognized a need to expand these studies, and the new Project Group CAPE-19-70 was activated in mid-1970 and assumed technical responsibilities for the particulate study at Battelle. A summary of the first annual report from Battelle Memorial Institute is included in the write-up for CAPE-19-70.

PROJECT CAPE-13-68 -- INSPECTION, MAINTENANCE, SURVEILLANCE AND ECONOMIC EFFECTIVENESS STUDIES

OBJECTIVE: To:

(a) Develop short-time interval exhaust emission test cycles for use in state inspection procedures and franchised inspection facilities.

(b) Develop inspection and maintenance procedures which will evaluate the visually observed and measured parameters having a primary effect on exhaust emissions.

(c) Evaluate the effectiveness of short test cycles (Item a) and inspection and maintenance procedures (Item b) in controlling emissions from vehicles in service.

(d) Optimize statistical and testing techniques for an effective customer's vehicle surveillance program.

(e) Model practical inspection, maintenance, and surveillance schemes for motor vehicle pollution control and make an economic-effectiveness comparison of the alternate combinations.

CONTRACTOR: TRW, Inc.

STATUS: In progress.

To insure the continued low-emission performance of motor vehicles after they leave the manufacturer, an effective system of periodic inspection and maintenance must be available that is least burdensome to the motorist in terms of cost and time. Accordingly, a comprehensive CRC program at TRW, Incorporated (with Scott Research Laboratories as sub-contractor) has been underway since June 1969 to develop acceptable methods for inspecting and maintaining cars with emission-control devices in the best possible condition, from the point of view of air pollution control. To date, over 250 vehicles have been inspected and the degree of maladjustment evaluated. Based on laboratory information being developed, the degree of improvement which could be obtained by various types of inspection followed by the maintenance indicated, or mandatory maintenance, has been estimated.

Preliminary general conclusions of the study are:

Vehicle Inspection Maintenance

- The six most effective engine parameters in a mandatory inspection/maintenance program are the idle adjustments (fuel-to-air ratio, idle rpm and timing), the secondary ignition system (when it is causing misfire), and the induction system components of the positive crankcase ventilation valve and air cleaner. The air reactor system should also be maintained on vehicles so equipped.

- Maximum emission reductions are achieved through direct inspection of engine and control system components followed by the maintenance of the six parameters described above. The cost of this inspection is high in relation to resulting emissions reduction, making this procedure less cost-effective than an exhaust emission inspection procedure.

- The most cost effective procedure uses an idle emission measurement to diagnose maladjustments of basic timing, idle fuel-to-air ratio, and rpm.

- State inspection lanes, at this time, appear to be more cost effective than franchised garages.

- Non-dispersive, infrared emission measurement instruments are preferred for state lane applications.

Vehicle Emission Surveillance

- The CO emissions variability, as reflected by the estimate of its population standard error, is larger than those for NO_x and HC emissions and generally will controll the sample size to be drawn from the general vehicle population.

- Relative to their mean emissions, both mass and concentration measurements, using the seven-mode driving cycle, have essentially identical within and between vehicle variability.

- Mass emissions (particularly CO) have significantly greater sensitivities to engine temperature state than do composite emissions.

- The most effective test procedure for conducting a surveillance program using the 1968 Federal test procedure is to condition the power train to a stable operating temperature and to perform a hot-cycle emission test using five-cycle replications.

Although it was originally planned to carry out extensive fleet tests as a second phase of the program in order to establish the cost-effectiveness of the maintenance procedures developed from the first phase of studies, the project group has recommended because of the rapidly changing control system technology, continuing upgrading of test techniques and performance standards (e.g., change in test cycle and mass emission measurement), and the imminent need to select optimum inspection and maintenance practices. It has been recommended and approved by APRAC that future CAPE-13-68 activity be directed toward improvement of the capability of the effectiveness model for accurately predicting the effect of various inspection/maintenance strategies, and toward maintaining the model in a state of readiness so that meaningful procedure evaluations and recommendations can be made at any future time.

An extended Phase I program has been developed and is currently under negotiation. The objectives of this program will be to strengthen deficiencies in the cost-effectiveness model by acquiring and introducing more definitive experimental data to:

- Describe more accurately the frequency and extent of engine and control device malfunctions and their associated emission signatures for vehicles in several regional populations.

- Predict the effects of maintenance on emission reductions for precontrolled and California 1971 NO_x - controlled vehicles.

- Describe the degradation of engine parameters with time and the associated change in mass emissions, as measured with the 1972 Federal procedure.

- Characterize the effectiveness with which specified maintenance will be performed by a commercial service organization.

The above data will be used to assess the effects of new technology, differing air quality criteria, and mass emission certification procedures on the choice of optimum inspection and maintenance procedures.

PROJECT CAPE-19-70 -- CHEMICAL AND PHYSICAL CHARACTERIZATION OF AUTOMOTIVE EXHAUST PARTICULATE MATTER IN THE ATMOSPHERE

OBJECTIVE: To determine the physical and chemical characteristics of particulate matter from internal combustion engines as a function of sampling procedure, engine operating conditions including emission control systems, fuel composition, and residence time in the atmosphere. Emphasis is to be placed on the study of particulate matter during its lifetime in the atmosphere.

CONTRACTOR: Battelle Memorial Institute.

STATUS: In progress.

In a program carried out under CAPE-12-68, Battelle Memorial Institute reported results from a limited exploratory study in an annual report dated January 29, 1970 (API Publ. 4039). To summarize, particulate matter was generated in a small single-cylinder engine using commercial leaded gasoline. Particle-sized fractions were collected with the Battelle cascade impactor wherein 0.25 microns were the smallest size collected before the final filter. Inorganic chemical analysis and physical characterization of single particles and/or aggregates were done by electron probe analysis and electron microscopy, respectively. Almost all particles were found to be aggregates which contained some electron-dense structures dispersed throughout a low-electrom dense matrix.

Calcium and phosphorus were found together in some of the larger particles, whereas iron was found in other relatively large particles. The most prevalent particles were $\lesssim$1.0 micron where lead was the major inorganic element and was associated with bromine and sulfur. Polynuclear aromatics appeared to be present in each impactor fraction analyzed, but a definitive analytical study was beyond the scope of the first-year study. Ultraviolet absorption microspectrophotometry is being applied to very small samples to determine the capability of this technique for chemical identification of certain components in single particles or small aggregates.

To insure that particulates examined are representative of those encountered in air pollution, Battelle in the second contract year has been instructed to purchase two 1970 model autos (one for leaded, another for lead-free fuels), to operate them on a chassis dynomometer in a cycle representative of urban driving, and to install essential sampling and analytical control (CO, HC, and total particulates) facilities. A sampling tunnel has been designed, constructed, installed, and is being tested for velocity and dilution profiles. CAPE-19-70 has met jointly with CAPE-12-68 and plans are being made with Battelle to reorient the work remaining in this second contract year toward the broadened objective of the CAPE-19-70 project which is responsible for characterization of auto exhaust particulate matter in continuing studies.

PROJECT CAPA-1-69 -- FACTORS AFFECTING REACTIONS IN ENVIRONMENTAL CHAMBERS

OBJECTIVE: To study how various design and operation variables affect the reactions which occur in environmental chambers.

CONTRACTOR: Lockheed Missiles and Space Company.

STATUS: In progress.

Research was initiated in February, 1970 to study the effects of surface and irradiation variables on photochemical reactions in simulated atmospheres containing simple mixtures of hydrocarbon and nitric oxide. The concept of the research program, as developed by the project group, has been divided into two phases. Phase I covers the design, fabrication, and testing of an irradiation chamber capable of accommodating controlled and independent variations in surface area, surface material, surface treatment, irradiation intensity, and spectral distribution.

Phase II covers execution of three experimental studies to delineate: (a) the effects of surface variables on photochemical reactions; (b)the effects of radiation variables on photochemical reactions; and (c) the influence of such factors as humidity, hydrocarbon concentration, NO_x concentration, and SO_2 concentration on the surface effects observed in study (a).

PROJECT CAPA-2-68 -- PLANT DAMAGE BY AIR POLLUTANTS

OBJECTIVES:

(a) Determine the nature and extent of damage produced in plants by air pollutants.

(b) Identify the principal sources of pollution which may cause significant plant damage and determine the economic losses resulting from such damage.

(c) Indicate the degree to which specific automotive emissions are responsible for plant damage.

CONTRACTOR: Stanford Research Institute.

STATUS: In progress.

During the past year, a program has been in progress at Stanford Research Institute to estimate the loss in dollars that occurs annually as a result of the effects of air pollutants on plants. The program has involved individuals trained in agricultural economics and in the physiological and pathological reactions of plants to air pollutants.

It was agreed that the study would be limited to the effects of ozone, peroxyacyl nitrates, nitrogen dioxide, sulfur dioxide, and fluorides, as these compounds appear to account for at least 90 percent of the damage to vegetation by air pollutants. It was also agreed that, in initial phases of the study, estimates of loss would be limited to the direct effects of these pollutants on yeild, quality, and marketability of important commercial crops, with losses for ornamental plants based on losses to vendors and not to homeowners.

Counties in the United States where potential sources of air pollutants seemed to exist whether those of generalized urban activity, such as automobiles, or specific single sources, such as industrial operations (smelters) were identified.

Dollar-loss estimates were made for each crop reported for each county where air pollution sources apparently existed. These estimates included losses due to (1) ozone, oxides of nitrogen, PNA, and (2) sulfur dioxide, and (3) fluorides.

A second-year continuation of this project is being conducted at Stanford Research Institute. It was recognized during the first year that inadequate information was available on many aspects of this project. Particular attention will, therefore, be given in the forthcoming year to visits which will be made to areas where air pollution effects are occurring so that present estimates may be verified or amended as a result of first-hand observation.

An attempt will be made to develop a method for estimating the economic value of losses to ornamental plantings and pasturage, as a result of air pollution.

Increased use will be made of state agencies, such as those in California and Pennsylvania, where specific attention is being given to crop losses.

Consideration will be given to improved procedures for identifying plant damage, including "hidden damage".

PROJECT CAPA-3-68 -- DIFFUSION MODEL OR URBAN ATMOSPHERE

OBJECTIVE: To develop a mathematical model which will predict the spread of automotive air pollutants thoughout a city containing both urban and suburban areas, and which can be extended to predict how the contamination from such a city will spread throughout neighboring geographical regions.

CONTRACTOR: Stanford Research Institute.

STATUS: In progress.

This project is designed to develop a method for predicting concentrations of air pollutants at any selected location throughout an urban area as a function of local meteorology and the distribution of pollution sources. It is limited to pollutants which result from automotive emissions, either directly or as the result of subsequent chemical or photochemical reactions. At any particular location, in addition to predicting long-term average exposure, the model is also expected to predict the percentage of the time at which hourly average concentrations above any specified level can be expected to occur. The methodology is being developed as a tool for city planning organizations so that they can predict the pollution patterns which might be expected to develop in any urban region as a result of predicted growth.

Although the ultimate aim of this program is to cover all types of automotive pollutants, as a first step it was decided to develop satisfactory procedures for predicting the dispersion of a chemically inert pollutant such as carbon monoxide. A contract for developing such a model was granted to Stanford Research Institute in April 1969. They were charged with developing and validating the model from existing information, with identifying the information needed to complete the validation of the model, and with designing a field program which would provide the missing information.

The working model was completed during 1970, and a report was published in September of that year (API Publ. 4065), describing the first stage of development. This receptor-oriented model incorporates diffusion submodels based upon both Gaussian-shaped and uniform vertical concentration profiles. Model inputs are traffic valumes on major streets and highways in the urban area, atmospheric stability, mixing depth, and wind speed and direction. Traffic volumes can be obtained from either past measurements or forecast values. Methods have been developed for estimating atmospheric stability and mixing depth from conventional (i.e., airport) hourly meteorological measurements and twice daily radiosonde data. Meteorological factors are assumed to be uniform throughout the urban area. The model can provide statistical summaries as well as hour-by-hour predictions. It has been applied to five different cities (St. Louis, Washington, Chicago, Cincinnati, and Denver) in several different ways to demonstrate its usefulness. The following different types of calculations, among others, were performed:

Maps of concentration isopleths for the five cities, based upon calculated concentrations at 725 points (25 X 25 grid).

Week-long sequences of calculated hourly concentrations at single points in each of the five cities.

Maps of concentration isopleths for St. Louis, based on forecasts of 1980 traffic, and two hypothesized levels of continued exhaust emissions.

Concentration frequency distributions for various averaging times and times of day for a location in St. Louis, based on a five-year (1960-64) meteorological record and historical, as well as forecast, traffic data.

The median and 90-percentile values of hourly concentration at nine St. Louis locations, based on the same data as above.

For validation purposes, the field concentrations calculated by the model have been compared with those measured at Continuous Air Monitoring Program (CAMP) stations in the five cities studied. These comparisons demonstrated that while the relative pattern of CO levels could be predicted for continuous periods as long as one week, the observed concentrations were usually higher than those predicted, particularly during peak periods. To some extent, these descrepancies can be attributed to inadequate input data for the model and to inaccuracies in the CAMP data. Primarily, however, they appear to result from the weakness of the model in treating diffusion from nearby sources, since the CAMP stations are located at ground level alongside busy downtown streets.

For the studies now underway in the second year of the project, SRI proposed to carry out carefully instrumented studies of CO concentration gradients along downtown streets and intersections to obtain information on the dispersion of CO from the street up to rooftop level. At the same time, they would be using a helicopter to study how the concentrations measured at rooftop relate to those over the city as a whole.

It was proposed that these studies first be carried out for a four-week period in San Jose, This site was selected because San Jose is a typical small city with rather uniform building heights, is one of the few cities equipped with a computerized traffic network which can provide accurate input information, and is sufficiently close to the SRI laboratories to facilitate the initial shakedown of the equipment and procedures.

By the end of October, 1970, the installation of the San Jose instrumentation was completed and all equipment operated smoothly. A San Jose report is now available as API Publ. 4092. A similar study is currently being carried out in the larger city of St. Louis to obtain data on city canyons of greater depth.

PROJECT CAPA-4-68 -- FATE OF CARBON MONOXIDE IN THE ATMOSPHERE

OBJECTIVE: To identify significant mechanisms by which carbon monoxide is removed from the atmosphere.

CONTRACTOR: Stanford Research Institute; Argonne National Laboratory.

STATUS: In progress.

While carbon monoxide (CO) is generally regarded as a nonreactive material under ambient atmospheric conditions, the worldwide level of CO in the atmosphere is actually much lower than would be predicted, based on annual emission rates. Thus, since increasing evidence indicates that the lifetime of carbon monoxide in the atmosphere is of the order of a few months and that production of CO by natural processes far exceeds that produced from combustion, the main focus of three CRC contract efforts in this area has been to learn more about the removal mechanism accounting for this short lifetime.

Biological studies at Stanford Research Institute (SRI) have confirmed that some soil microorganisms act as a CO sink and are very effective in removing carbon monoxide from the atmosphere.

Preliminary tests were conducted with a soil mixture used in greenhouses at SRI-Irvine for potted plants. Two liter of potting soil, contained in specially constructed plastic atmospheric chambers, depleted CO concentrations in test atmospheres from 120 parts per million (ppm) to zero ppm within 3 hours, confirming the hypothesis that the soil may act as a sink for CO. Tests conducted in the field at ambient temperatures over undisturbed soil and attendant grassy vegetation showed similar results, indicating that the effect was not just a laboratory phenomenon.

The next research task was to determine what elements of the solil are responsible for CO uptake. A series of experiments was conducted. Sterilazation of potting soil with steam completely inhibited the effect. The phenomenon increased with higher temperatures to a maximum rate at 30C, and decreased at still higher temperatures. Anaerobic conditions completely inhibited the effect, as did abnormally high salinity and soil treatment with a mixture of antibiotics.

All of these effects suggest that the mechanism in the soil responsible for CO uptake is biological rather than physical, and the possible role of soil microorganisms such as bacteria and fungi is suspected.

An analysis of 17 different soils collected in California, Hawaii, and Florida showed that the ability of a soil to take up CO is closely dependent upon the amount of organic matter (plant debris, etc.) contained in the soil. This observation also implicated soil mocroorganisms, which thrive in high-humus soils. CO from the atmosphere equivalent to more than 500 tons CO per year per square mile.

Research is in progress to determine which soil microorganisms are respondible for the observed CO uptake. Of 75 species of fungi and bacteria isolated from the soil near Lake Arrowhead, California, several of the fungi species were found to have considerable capacity to remove CO from test atmospheres in pure cultura. Tests are continuing with isolates from other soils.

An additionsl study of carbon monoxide in the atmosphere, with special emphasis on the kinds and extent of natural sources, is being carried out at Argonne National Laboratory. Extensive sampling of the atmosphere, and isotopic analysis of both carbon and oxygen in the contained CO indicate the existence of atmospheric CO with three different isotopis compositions of which at least two, and possibly all three, are different from automotive CO in their isotopis composition. The relative amounts of these different types of CO vary depending on latitude, season, possibly time of day, and trajectory of previous history of the air mass. One of these types of CO, although not the most abundant, is probably of marine origin. The source of the other principal types of atmospheric CO is unknown at the present time. Investigation of various emissions from the biosphere has not yet revealed any CO that can be identified as the major source of atmospheric CO.

The principal effort in studying CO emissions from the biosphere has been made on marine CO and emissons from trees and plants. Preliminary results indicated soil and humus emissions to be less sugnificant than those of trees or ocean water. Nine samples of marine CO collected from three locations showed variable isotopic composition; but their average value is quite consistent with one component of atmospheric CO. Twelve samples of emissions from trees and underground plants have been analyzed, and in some cases, CO was detected. The isotopic compositions were also variable and showed no definite correlation with the various types of CO observed in atmospheric samples.

Argonne also is investigating the production of CO by algae. It is estimated that the off-gases from the algae culture tank will contain up to 50 ppm of CO in a mixture of nitrogen (95%), carbon dioxide (5%), and oxygen (200ppm). A sensitive and rapid gas chromatographic procedure has been chosen for the quantitative determination of CO. This method first removes the carbon dioxide, after which the CO is converted catalytically to methane, and the methane is determined by gas chromatography.

Chemistry studies completed by GCA Corporation have indicated that the ozone-carbon monoxide reaction is too slow to be significant as an atmospheric removal mechanism. Based upon the results obtained by GCA, it was estimated that transport of CO to the stratosphere, with subsequent conversion to carbon dioxide in the stratosphere, is a significant removal process but would result in a 10-year lifetime if it were the only removal mechanism.

PROJECT CAPA-5-68 -- LIGHT HYDROCARBONS IN THE ATMOSPHERE

OBJECTIVES: (a) Analyze ambient air samples for hydrocarbons in a broad spectrum of locations to determine the relative amounts of these hydrocarbons as compared with the distribution reported from known sources, including automotive exhaust.

(b) Improve the chromatographic column-freezeout technique to extend the range of hydrocarbons to the higher carbon number so as to include aromatics and terpenes.

(c) Irradiate samples of ambient air and determine the disappearance rates of the hydrocarbons.

CONTRACTOR: University of California (Riverside).

STATUS: In progress.

The study of ambient air hydrocarbons at the Air Pollution Research Center at the Riverside campus of the University of California is emphasizing extension of the analytical capability to additional hydrocarbons and oxygenates. A column which separates most of the aromatics in the gasoline range and gives peaks for acetone and acetaldehyde (presumably reaction products) is now in operation. Some measurements of these materials in ambient air have been made, and ambient air samples have been irradiated. The aromatic concentrations are reasonable (toluene ≅ 10 parts per billion (ppb), etc.) and the rates of disappearance under irradiation are as expected. The acetone and acetaldehyde concentrations are somewhat larger than anticipated (∼20ppb). Thus far in the program there have been no opportunities to sample unreacted air to verify the absence of these reaction products. A new and better chromatograph has been obtained for this analysis. Better temperature control of the column should permit improved aromatics analysis.

The computer program used to match fuel and fuel vapor compositions to ambient air distribution has been extended to a larger group of hydrocarbons. Good results have been obtained by using fuel compositions derived from early morning unreacted air samples. It is planned to add the aromatics to this treatment as soon as good early morning air samples can be obtained.

PROJECT CAPA-6-68 -- HAZE FORMATION: ORIGINS AND IMPORTANCE TO AIR POLLUTION

OBJECTIVES: (a) Conduct a literature study of atmospheric haze in relation to air pollution, leading to a system for classifying and identifying various types of atmospheric haze.

(b) Suggest research projects which can improve the ability to classify and identify various types of atmospheric haze, with particular attention to distinguishing and identifying photochemical haze derived from automotive sources.

CONTRACTOR: Science Spectrum, Inc.; Battelle Memorial Institute.

STATUS: In progress.

A report entitled "Atmospheric Haze: A Review" was prepared by Bolt, Beranek and Newman (API Publ. 4043) contains a review of the important aspects of haze formation and various techniques for measuring hazes. The topics which were critically reviewed were haze components, mechanisms of haze formation, distribution and movements of atmospheric aerosols, and optical and other methods for quantitatively describing aerosols.

Contracts were awarded to two research organizations for the initiation of experimental programs directed toward finding a method to determine whether an atmospheric haze originated from natural or automotive sources.

During August and September, 1970, Battelle Memorial Institute personnel conducted a field sampling and measurement program at two sites in New York City. Part of this work was conducted in cooperation with Scott Laboratories which was measuring air pollutants in New York City under another APRAC project. Battelle measured light scattering and collected aerosol samples for analysis, while Scott was obtaining air pollutant data which will be used in the interpretation of results.

In October, 1970, the Battelle Mobile Air Quality Laboratory was located at a site in the Blue Ridge Mountains near Mt. Mitchell. Samples of natural aerosols were collected and, concurrently, light scattering data were obtained.

Thus, samples of hazes from both natural and man-made sources have been collected. Hopefully, the analysis of these samples may identify a component which will differentiate between types of haze.

As an additional approach to the problem, aerosols from specific sources will be generated in Battelle's 610-cubic-foot smog chamber. These hazes will be analyzed for components which may characterize the source.

The second contract was awarded to Science Spectrum, Inc. which is determined light scattering from single aerosol particles using a unique optical instrument. The aerosols under investigation were obtained from both natural and automotive sources. A final report is now available as API Publ. 4091.

PROJECT CAPA-7-70 -- MEASUREMENTS OF ATMOSPHERIC POLLUTANTS IN URBAN AREAS

OBJECTIVES: (a) Provide measurements needed to determine the effect of varying concentration levels of nitrogen oxides on atmospheric reactions.

(b) Obtain ground level and airborne measurements at several locations in Los Angeles and other urban areas to determine variability in concentration and composition by hydrocarbons.

(c) Provide measurements of the rates and products under atmospheric conditions.

CONTRACTOR: Scott Research Laboratories; Stanford Research Institute.

STATUS: In progress.

During 1968, Scott Research Laboratories conducted a comprehensive survey of the Los Angeles Basin atmosphere. To obtain aerometric data, two mobile trailer-type laboratories were fabricated and instrumented for both continuous and periodic monitoring of a large number of pollutants, photochemical products, and pertinent meteorological factors. In addition, an instrumented aircraft sampled several altitudes above the two ground sites to measure air temperature, relative humidity, oxidants, and incoming and outgoing ultraviolet irradiation. A comprehensive report containing a complete description of the study methodology and in-depth analysis of the voluminous data that were collected has been issued as API Publ. 4027, 4028.

Using the knowledge gained from the 1968 program, additional work in the subject area was carried out during the 1969 smog season by Scott Laboratories to further study the gaseous constituents involved in the photochemistry and kinetics of atmospheric reactions in the Los Angeles Basin by means of ground level and airborne sampling and analysis measurements, as well as by varied meteorological observations. A final report covering the 1969 program design, methodology, data summary, and general discussion has been prepared by Scott Laboratories. Detailed analysis of the 1968 and 1969 data assembled by Scott has been provided by General Research Corporation (GRC).

The data analysis report was completed by GRC. The final report issued in July 1970 contained a series of recommendations for future studies. These recommendations were provided to Scott Research Laboratories to aid in planning new field investigations.

In early 1970, the scope of the CAPA-7 project was expanded to permit aerometric studies in various urban areas of the United States. In line with the need for a more extensive investigation on the East Coast, Scott Research Laboratories was selected to carry out an experimental study in the New York-New Jersey area during the summer of 1970 to obtain measurements similar to those secured in the Los Angeles Basin during 1968 and 1969. The measurements were conducted during 40 days at each of three ground-level sites during the summer and the fall of 1970. Tetroons were launched on 20 days from one of several selected sites and samples were collected from a helicopter following the tetroon. Measurements of particulates by Battelle Memorial Institute for the CAPA-6-68 haze formation project were to be made in support to the overall effort. Information from this work is now being prepared, and it is planned to subject the results to data analysis for comparison with the Los Angeles Basin results.

A separate effort was initiated with Stanford Research Institute to review and appraise patterns of smog over the San Francisco Bay area. Preliminary air sampling is to be conducted, and the contractor will analyze all available results to determine whether the patterns of photochemical smog provide a unique opportunity to investigate the processes of smog formation under ambient air conditions.

PROJECT CAPM-3-68 -- EFFECTS OF CARBON MONOXIDE ON HUMAN AND ANIMAL BEHAVIOR

OBJECTIVE: To increase knowledge of the effects of exposure to air pollutants -- in particular, carbon monoxide -- with special emphasis on impairment of behavior not heralded by symptoms.

CONTRACTOR: Medical College of Wisconsin.

STATUS: In progress.

The Medical College of Wisconsin (formerly Marquette School of Medicine) was selected to carry out an experimental study designed to assess human response to a wide range of carbon monoxide concentrations. Special emphasis was given to impairment of functions not accompanied by subjective symptoms. An exposure-chamber technique and related methodology were used in a series of behavioral and performance experiments to establish various dose-response relationships in man. They included a test of the ability to perform driving tasks, using a driving simulator.

Contract work was initiated in September 1968, and a report on the results of the first year's work has been submitted. In this program, human volunteers were exposed to carbon monoxide (CO) concentrations of less than 1, 25, 50, 100, 200, 500, and 1,000 parts per million (ppm) for periods of one-half to 24 hours. Significant conclusions from these studies include (1) no untoward effects were observed in sedentary males exposed to 100 ppm for eight hours which produced carboxyhemoglobin saturations in the range of

11 to 13 per cent; and (2) exposures producing carboxyhemoglobin saturations greater than 15 to 20 per cent resulted in delayed headaches, changes in the visually evoked responses and impairment of manual coordination. The results of these experiments have been incorporated in four separate papers which were published in the "Archives of Environmental Health," 21:154-180, August 1970 (API Publ. 4052).

One of the prime tasks in the second year of research at the Medical College of Wisconsin was to investigate the effect of exercise, with its increase in tidal volume, upon the uptake of CO in healthy male and female subjects. This work was completed and it was discovered that the Coburn, Forster, and Kane equation could predict within 1 per cent carboxyhemoglobin the actual amount of carbon monoxide absorbed during exercise.

It was observed that the increase in carboxyhemoglobin saturation in females occurred more rapidly than in males, due primarily to the difference in tidal volume and total body mass of the female subjects.

The second major task of the second year of research was to look for differences in CO effect on humans, male and female. In the 72 experiments conducted, none were observed. Included in the battery of testing procedures were all of the tests used during the first year, with the exception of the American Automobile Association (AAA) driving simulator test. Also included in the second year's endeavor was the Flanagan arithmetic test which was administered during and following all exposures to CO, up to a concentration of 200 ppm for four hours. No decrement in performance was observed. Thus, the results did not confirm the decrement in arithmetic ability reported in previous literature.

Midway through the research year, it became apparent that one possible reason for differences in the findings from those observed by other investigators could be the means by which CO was administered to human subjects. Previous investigators, for example, had dosed the subjects with high concentrations of CO for short intervals of time. Therefore, a series of 13 experiments using high concentrations of CO were conducted so that, in the third year of work, the variable of rate of absorption could be evaluated. Six healthy volunteers were exposed to CO concentrations ranging from 1,000 ppm to 35,600 ppm for periods of 10 minutes to 45 minutes. Carbon monoxide was rapidly absorbed, and the increase in per cent carboxyhemoglobin saturation in venous blood/liter of CO mixture inhaled could be accurately predicted by the equation: $\text{Log}\ (\Delta\%\ \text{carboxyhemoglobin}) = 1.03672\ \log\ (\text{ppm CO}) - 4.48155$.

The abrupt increase in carboxyhemoglobin concentration of 11.6 and 9.1 per cent saturation by two subjects produced an immediate onset of mild frontal headache. One subject exposed to 35,600 ppm demonstrated a very slight depression of the J-point of his electrocardiogram, together with very minimal straightening of the first portion of the t-wave. This occurred 20 seconds after the exposure had started and persisted for 10 minutes after exposure. Neither the spontaneous nor the evoked electrical activity of the brain exhibited significant changes which could be attributed to CO exposure over the range studied.

In order to study the effect of CO on the time sense, the Beard-Wertheim tests were utilized. The test consisted of three sequences of 25 tests each, initially performed in a group setting with 20 subjects divided into two separate groups for the "double blind" random exposures to $<$2, 50, 100, and 200 ppm. There was no significant difference in the reactions of the two groups.

Subjects also are being tested while isolated in an audiometric booth. For a 90% probability of detecting a 10% difference in the mean score (approximate shift of two in the average score), testing of 20 isolated subjects is required. To date, "double blind" testing of eight subjects has been completed, a sufficient number of allow the conclusion that the impairment in time discrimination reported previously in "single blind" experiments is not a valid observation.

All subjects performed the Marquette time estimation tests in the group setting, in an isolated situation, and in the audiometric booth. No decrement in performance was observed.

General Motors Corporation has made available to this program their physiological readiness-to-drive tester which allows the evaluation of the near-term memory, secondary surveillance task performance, and simple and complex reaction time tasks. The use of this test device has added a new dimension to the evaluation of the effect of CO upon the human brain and, to date, exposures to CO resulting in carboxyhemoglobin concentrations of between 15 and 20% have shown no decrement in performance.

The initial investigations studying the effect of low doses of alcohol (0.6 ml/kg) midway during a four-hour exposure to 200 ppm have commenced. Since this is being done as a "double blind" experiment, the results have not yet been analyzed.

Papers detailing the results of these studies were presented at three national forums: the Annual Meeting of the American Industrial Hygiene Association, the Annual Meeting of the Society of Toxicology, and the Conference on Toxicology sponsored by Wright-Patterson Air Force Base.

PROJECT CAPM-4-68 -- EFFECTS OF CHRONIC EXPOSURE TO LOW LEVELS OF CARBON MONOXIDE ON THE CARDIOVASCULAR SYSTEM

OBJECTIVE: To obtain quantitative correlations between chronic exposure levels with carbon monoxide and physiological parameters of the heart and blood.

CONTRACTOR: Jefferson Medical College of Philadelphia.

STATUS: In progress.

The Jefferson Medical College of Philadelphia was selected to conduct a study of the effects of chronic exposure to low levels of carbon monoxide on the cardiovascular system of dogs. The program called for initial studies of CO levels of 100 parts per million (ppm) to be performed on two groups of animals (normal and those with induced coronary disease). The first experiment was concluded at the end of January, 1970, after 15 weeks of continuous exposure. The four treatment groups included: (a) 12 dogs infarcted with Latex spheres exposed to 100 ppm of carbon monoxide (CO), (b) 6 dogs infarcted with Latex spheres exposed to ambient air, (c) 12 non-farcted dogs exposed to 100 ppm CO, and (d) 6 non-infarcted dogs exposed to ambient air.

Dogs exposed to 100 ppm of CO maintained carboxyhemoglobin levels of about 12 per cent. Dogs exposed to ambient air averaged about 1 per cent carboxyhemoglobin.

None of the infarcted dogs exposed to CO showed any clinical or laboratory evidence of change from their stabilized infarct patter. None of the control animals showed evidence of CO effect.

After sacrifice, all of the animals injected with Latex spheres showed significant healed infarcts. Five of these animals also showed more recent infarcts, estimated to have occurred three to four weeks before sacrifice (11 to 12 weeks after exposure began). Four of these animals were in the infarcted CO group and one was in the infarcted control group. None of the non-infarcted animals showed pathological changes in the heart. Pathological studies of other organs have not yet been completed.

In view of the fact that these differences are not considered statistically significant, the second group of dogs was prepared in the same manner (18 dogs injected with Latex spheres and 18 untreated animals), stabilized for eight weeks or more and divided into four treatment groups as before. A final report on the initial study has been completed (API Publ. 4096). In early April 1970, exposures were started at 150 ppm of CO or ambient air, as outlined, and the exposure period was extended to 26 weeks. The animals were sacrificed in mid-October, and analysis of the data is underway. A final report should be available in early 1972.

A third group of animals prepared in the same way is being subjected to 50 ppm of CO (with same type controls), plus exercise at regular intervals beginning 4 weeks after CO exposure starts. This phase of the study was concluded in April 1971 and a final report is expected in February, 1972.

PROJECT CAPM-5-68 -- TOXICITY OF POLYNUCLEAR AROMATIC HYDROCARBONS IN THE LUNG

OBJECTIVE: To study the role of some physiochemical characteristics of particulates in relation to the effect of respiratory carcinogenesis. The role of particulate size of dusts and that of excess load of inert dusts in lungs are to be major aspects under study, with biological tests, including inhalation experiments, to constitute a final means of evaluation.

CONTRACTOR: Eppley Institute for Research in Cancer of the University of Nebraska College of Medicine (Dr. Shubik).

STATUS: In progress.

Contract work to ascertain whether air pollutants will produce lung cancer in test animals is being conducted by the Eppley Institute for Research in Cancer of the University of Nebraska College of Medicine. Progress to date has shown that cancer of the lung ca be readilty induced in hamsters by repeated intratracheal installations of a mixture of iron oxide (hematite) and benzo(a)pyrene, and that a dose relationship exists between the number of installations and the incidence of tumors. It has also been found that the presence of hematite alone in the lung induces bronchiogenic carcinoma when diethylnitrosamine is injected subcutaneously, but neither hematite nor diethylnitrosamine induces tumors of the lung when injected alone. These findings suggest that particulate matters may have a more important role in the causation of lung cancer than hitherto suspected.

Work now in progress is desinged to test the role of hematite in the previous system and to evaluate the influence of carbon black and aluminum oxide in interaction with benzo(a)pyrene. Since the research to date at the Eppley Institute has involved the use of pure compounds alone and pure compounds in conjunction with well characterized particles, it is planned now to study the effects of actual auto exhaust particulates in the lungs. Accordingly, arrangements are underway with a proposed contractor having experience in exhaust particulate collection and analysis to provide suitable quantitites of particulates in two size fractions for the CAPM-5-68 study.

PROJECT CAPM-6-68 -- SYNERGISTIC EFFECTS IN CERTAIN AIRBORNE SYSTEMS

OBJECTIVE: To investigate the possible joint physiological action in five common air pollutants in animals by simulating exposure to both high concentrations for a short time and at realistic levels encountered in urban air for long periods of time.

CONTRACTOR: Hazelton Laboratories.

STATUS: In progress.

To investigate the possibility of some form of synergistic effect occurrring in an organism when exposed to a mixture of irritants or toxicants, a study is underway at the Hazleton Laboratories to determine the biological effects on experimental animals of selected air pollutants peculiar to most urban environments. The objective of the program is to evaluate any toxic actions which develop, and to ascertain the presence, nature, and degree of interactions (especially synergism) under short-term acute and long-term chronic exposure conditions. The pollutants being investigated, singly and in combination, include carbon monoxide, nitrogen dioxide, sulfur dioxide, and two particulates (PvClBr and CaSO4).

The short-term (acute) testing phases of the work were completed in early 1968, during which period the concentration levels of each pollutant for the chronic phase were selected. The long-term (chronic)phase of the study followed, to determine if chronic effects can be produced in the test animals at pollutant levels approximating those found in ambient atmospheres. Using the acute tests as a guide, monkeys were exposed to the selected pollutants (either singly or in combination) over a two-year period, and rats were exposed to the same pollutants for one year. Various highly sophisticated physiological procedures to assess exposure effect were employed. Use of electronic data processing equipment produced immediate on-line data analyses of the physiological measurements performed on the test animals, thereby increasing the precision of the evaluation and also enabling the detection of effects that by normal techniques would be masked by test variability.

The long-term (chronic) animal exposures were completed in September 1970, and the evaluation of data is underway, with reports of findings expected to be released in early 1972.

PROJECT CAPM-8-68 -- DETERMINATION OF CARBOXYHEMOGLOBIN IN VARIOUS SEGMENTS OF THE POPULATION

OBJECTIVE: To obtain information on the carboxyhemoglobin range which exists in a corss section of the U.S. population.

CONTRACTOR: Medical College of Wisconsin; Columbia University.

STATUS: In progress.

The contract for this study was awarded to the Medical College of Wisconsin (formerly Marquette School of Medicine), directed by Richard D. Stewart, M.D.

Work on the project began in mid-1970. A series of studies was initiated to investigate the problems of shipping blood and breath samples from remote parts of the United States to the laboratory in Milwaukee for analysis.

During September, 1970, the orientation of the two investigators who were to conduct the field studies was completed and a pilot study was initiated in Milwaukee.

During October, 1970, sampling was completed in Milwaukee and blood collection was begun in Chicago. The latter program was completed by mid-November. The blood collection program in fifteen cities is completed. No difficulty has been encountered with the shipment of blood samples in the specially designed paper envelopes, and quality control has eliminated major instrumentation problems.

The analysis of all the Milwaukee and Chicago data is completed and will be included in the annual report.

In a separate contract effort, Columbia University has completed a study of the relationship between ambient air CO and carboxyhemoglobin levels to establish whether human panelists attain concentrations of blood carboxyhemoglobin similar to those attained by taxicab drivers in equal exposures, and if these relationships differ for smokers and non-smokers. The results of this study will help to ascertain the usefulness of panelists in similar studies elsewhere which could eliminate the need for specific occupational groups.

PROJECT CAPM-9-69 -- EFFECTS OF LOW LEVELS OF CARBON MONOXIDE UPON HUMANS PERFORMING DRIVING TASKS

OBJECTIVE: To determine the effects of low levels of carbon monoxide upon humans performing complex tasks, with particular emphasis on actual driving.

CONTRACTOR: Ohio State University; Harvard University.

STATUS: In progress.

Two universities have been selected to study the effects of low concentrations of carbon monoxide (CO) upon human performance, particularly in regard to the task of driving an automobile. The main objectives of the investigation being carried out at Ohio State University are to (a) develop accurate and rapid methods for measuring carboxyhemoglobin (expressed as percentages of hemoglobin combined with CO), (b) determine the effects of low concentrations or carboxyhemoglobin (COHb) on physiological performance, complex psychophysiological and psychomotor skills, and driving skills and judgement on the highway, (c) determine the predictability of decline in driving skills based on results of psychophysiological testing in the laboratory, and (d) determine the interaction effects of carboxyhemoglobin content in the blood and fatigue with time and with smokers versus non-smokers during the driving task.

The second study is being performed at Harvard University. The major purpose of the investigation is to study the effects of small amounts of CO on driving performance. The first phase of the study involves the utilization of tests which might be expected to influence the accident susceptibility of a driver. This part of the program is to be carried out in environmental test chambers at the Harvard School of Public Health. The procedures to be developed and standardized would be those found in previous studies to be most likely to influence the visual reactions and decision-making responses of the driver. After medically screening the 60 subjects to be used, each is to be tested during two control sessions and two sessions in which the concentrations of CO in the inhaled air would be increased. The COHb would be approximately eight to ten per cent in one period and 16 to 20 per cent in the second. Consideration would be given to the age and previous smoking habits of each subject. The next phase of the project is to repeat aspects of the tests developed in the laboratory investigation during actual driving over a test course, and under other appropriate conditions.

PROJECT CAPM-10-71 -- EFFECTS OF LOW LEVELS OF NITROGEN OXIDES UPON HUMANS

OBJECTIVE: To obtain a scientific review of available information on the toxicological effects of low levels of nitrogen oxides upon humans and to recommend directions for future research.

CONTRACTOR: To be selected

STATUS: To be initiated

The original intent of this project was to request the National Academy of Sciences to review the literature and other information on the effects of nitrogen oxides exposure on man. Because the Academy was unable to undertake the project in 1970 and because the government prepared such a review, it was decided to employ this document in guiding CRC research projects in this area.

The effects of low levels of oxides of nitrogen upon humans will be investigated in three residential areas of a single urban county in the southeastern United States before and after emissions from a large point source of nitrogen dioxide are controlled. These areas will represent an exposure gradient for ambient air pollution by oxides of nitrogen. Air monitoring stations are already located in each study area. Health indicators to be investigated include frequency of chronic respiratory disease symptoms, frequency of acute respiratory illness, and the ventilatory performance of school children. The effect of such covariants as residentail history, cigarette smoking, occupational exposure to dusts or fumes, and socio-economic status, will be delineated. Selection of a contractor is under consideration.

PROJECT CAPM-11-71 -- EFFECTS OF LOW LEVELS OF OXIDANTS UPON HUMANS

OBJECTIVE: To obtain a scientific review of available information on the toxicological effects of low levels of oxidants upon humans and to recommend directions for future research.

CONTRACTOR: To be selected.

STATUS: To be initiated.

The originial intent of this project was to request the National Academy of Sciences to review the literature and other information on the effects of oxidant exposure on man. Because the Academy was unable to undertake the project in 1970 and because the government prepared such a review, it was decided to employ this document in guiding CRC research projects in this area.

The effects of low levels of oxidants upon humans will be investigated in three communities selected to reflect an exposure gradient for ambient oxidant air pollution. Concomitant air monitoring data for oxidants, oxides of nitrogen, sulfur dioxide and suspended particulates must be obtained for each study community. Health indicators to be investigated include frequency of chronic respiratory disease symptoms, frequency of acute respiratory illness, ventilatory performance of school children and frequency and severity of asthma attacks in a panel of patients. The effect of such covariates as residential history, cigarette smoking occupational exposure to dust and fumes, socioeconomic status, and meteorologic variables will be delineated A contractor has not been selected.

PROJECT CAPM-12-69 -- INFLUENCE OF CARBON MONOXIDE LEVELS UPON INCIDENCE OF MOTOR VEHICLE ACCIDENTS

OBJECTIVE: To determine if a relationship exists between the carbon monoxide exposure of motor vehicle operators and the incidence of motor vehicle accidents.

CONTRACTOR: To be selected.

STATUS: To be initiated.

This project was established as a result of the recommendation included in the National Academy of Sciences review carried out under former CRC Project CAPM-2-68 covering the effects on human health, behavior, and performance of chronic exposure to low levels of carbon monoxide (CO). As suggested by the NAS review, in addition to measured or estimated carboxyhemoglobin levels, the smoking history, drug history, and measured blood alcohol levels of drivers involved in motor vehicle accidents should be considered along with those of comparable individuals not involved in accidents. Accordingly, it is planned to compile and analyze pertinent existing data in this subject area to determine if a relationship exists. A contractor will be selected shortly to (a) prepare an evaluative summary of previous work on the etiology of automobile accidents with regard to the potential role of carbon monoxide as an etiological factor in such accidents, both alone and in combination with other factors, and (b) prepare a specific research plan for definitively evaluating the role of CO in the causation of a sample of accident events.

PROJECT CAPM-13-69 -- EFFECTS OF CARBON MONOXIDE EXPOSURES UPON MYOCARDIAL INFARCTION FATALITY RATES

OBJECTIVE: To conduct an epidemiological study to determine the effects of carbon monoxide exposures upon myocardial infarction fatality rates.

CONTRACTOR: Johns Hopkins University.

STATUS: In progress.

This project was initiated as a result of the recommendation included in the National Academy of Sciences review carried out under CRC Project CAPM-2-68 covering the effects on human health, behavior, and performance of chronic exposure to low levels of carbon monoxide. Johns Hopkins University has initiated a study covering all admissions to coronary care units and all deaths outside hospitals of individuals less than 70 years of age from a defined area. Sudden coronary deaths and myocardial infarction deaths are to be identified by clinical, autopsy, and interview techniques. Carbon monoxide is to be monitored by carboxyhemoglobin determinations from blood collected on hospital admission or by the medical examiner. Micro-environmental investigation of home and work locales is to be conducted on a sample of cases. Ambient air quality data from a network of stations monitoring carbon monoxide, particulates, sulfur dioxide, oxides of nitrogen, and oxidants will detail air pollution exposure. Important therapeutic, personal, demographic, temperal and meteorologic covariants are to be considered. The effect, if any, of carbon monoxide exposure upon the incidence and natural history of sudden coronary deaths and myocardial infarction can then be ascertained.

Data collection for the project is now underway.

II-84

WILDLIFE CONSERVATION LIAISON COMMITTEE

WILDLIFE GRANT

OBJECTIVE: To study waterfowl ecology involving the emperor goose and petroleum development in the Yukon-Kuskokwim Delta area of Alaska.

CONTRACTOR: Charles M. Kilpatrick, Purdue University, post-doctoral work.

STATUS: In progress.

No report

WILDLIFE GRANT

OBJECTIVE: To determine the effects of treated and untreated oil on developing shellfish larvae.

CONTRACTOR: Richard S. LeGore, candidate for Ph.D. in the College of Fisheries, University of Washington.

STATUS: In progress.

No report

DIVISION OF REFINING

PROJECT -- WATER MANAGEMENT PROJECT

OBJECTIVE: To develop the cost-benefit relationships involved in selecting an optimum water management program to meet the specific requirements of a refinery.

CONTRACTOR: Rex Chainbelt, Inc., Milwaukee, Wisconsin.

STATUS: Completed.

The project has been completed and the report has been distributed to the members of the Committee on Refinery Environmental Control.

This report encompasses an extensive literature search pertaining to refinery water uses and waste characteristics of the water degraded through each refinery use. It also covers the unit processes and unit operations applicable to the treatment of wastes obtained either for discharge or for reuse within the refinery.

The report sets forth mathematical models which enable the evaluation of alternatives and the optimization of a water management plan to meet specific discharge or reuse requirements as a function of local refinery variables and factors. It also contains alternative process flowsheets for wastewater treatment systems within refineries.

At present, the Committee is attempting to validate the outcome of this project.

III. ABSTRACTS OF COMPLETED PROJECTS

EF-1 (API Publ. 4080) -- Recommended Procedures for Estimating Evaporation and Handling Losses of Volatile Petroleum Products in Marketing, July 1971

A report prepared by Crossley Surveys, Inc. for API contains data forms and evaluation procedures for losses from fixed roof tanks, floating roof tanks, other tanks, loading losses, losses from filling service station tanks, and losses from transfer pumps. Tables, monographs, graphs, and 10 references.

EF-2 (API Publ. 4017) -- Aerosol Formation and Visibility Reduction in Photochemical Smog, a literature survey, August 1969

The formation of aerosols in the atmosphere has been of interest and a number of publications have appeared in the literature in the past several years. API sponsored a study on vehicle emissions as related to aerosol formation in the photochemical smog processes. This literature survey was conducted to determine what is known concerning aerosol formation resulting from hydrocarbons present in motor gasoline and exhaust emissions from these fuels. It contains reviews on abstracts from various literature sources such as the *Air Pollution Control Association Journal*.

EF-3 (API Publ. 4077) -- Mathematical Expressions Relating Evaporative Emissions from Motor Vehicles to Gasoline Volatility (Parameters), summary report, March 1971

Expressions were developed by Scott Research Laboratories, Inc. for API for cars without evaporative emission control devices in the Los Angeles, Chicago, Houston, and New York urban areas. May-October weighted average emissions were correlated with a nonlinear function of the Reid vapor pressure, the volume per cent distilled at 160°F in an ASTM distillation, and the maximum diurnal ambient temperature. The simple expressions found for each urban area predicted evaporative emissions from different gasolines and for different diurnal ambient temperature regimes with a standard error less than 5 per cent. A general expression was also found for all cities combined, and the total weighted average evaporative emissions were calculated by a general model. The general expression can also be used to estimate the contribution of evaporative emissions to atmospheric hydrocarbon for different urban areas. Graphs, tables, and 14 references.

EF-5 (API Publ. 4002) -- U.S. Motor Gasoline Economics: Vol 1 -- Manufacture of Unleaded Gasoline, June 1967

This is a result of one of many research projects on air conservation supported by API. This report investigates the potential economic effects on the domestic refining industry that would result from completely eliminating the use of lead additives in motor gasoline. The report summarizes the economic results; gives details of cost and investment results; outlines raw material details and energy requirements; discusses changes in gasoline composition, volatility, and octane specification effects and the impact on petrochemical feedstock costs. Technical documentation is included. (245 pages, hard cover.)

EF-5 (API Publ. 4003) -- U.S. Motor Gasoline Economics: Vol 2 -- Volatility Changes and Olefin Reduction, November 1967 (revised December 1968)

This volume reports the results of an investigation into the costs and investments required to modify the characteristics of present gasolines. The study covers the economic effects of changes in volatility characteristics, removal of low-boiling olefins, and the interaction of lead-alkyl removal and decreased volatility. Included are investments required for new refinery processes, the increase in overall refining costs, the effect on crude oil and other hydrocarbon resources, the effect on motor gasoline composition and characteristics, the effect of geographic location, the effect of refinery size, and the directional effect on natural gas liquids and petrochemicals.

EF-5 (API Publ. 4081) -- The Economics of Manufacturing Unleaded Motor Gasoline 1969; January 1971

These have been determined by Bonner & Moore Associates, Inc. for American Oil Co., Atlantic Richfield Co., Marathon Oil Co., Mobil Oil Corp., and Sun Oil Co., by updating the economics reported in a 1965 study for API. For 1969, the added cost of manufacturing unleaded gasoline for three refinery models of 30,000-200,000 barrels per day (bbl/d) capacities is $0.0279 gallon average, compared with the 1965 value of $0.0213 gallon or $0.0231 as reevaluated according to present method.

For 1969, an additional investment of $4,797,000,000 is needed compared with the 1965 value of $4,235,000,000 or $3,849,000,000 as reevaluated. The distribution of added costs for making unleaded gasoline is identified in five interrelated cost-affecting categories. A study of the economic effect of added octane on a 200,000 bbl/d Gulf Coast refinery model shows that an octane specification increase of 0.5 on the unleaded motor gasoline pool raises the cost by $0.0046/gal or $0.39/octane bbl. In a leaded environment, typical costs range from $0.05 to $0.06/octane bbl. Tables.

EF-6 (API Publ. 4006) -- Polynuclear Aromatic Content of Vehicle Emissions, August 1967

This report contains information on the formation of polynuclear aromatic (PNA) compounds in automobile engines and evaluates the probable effects of engine and fuel variables on formation of these compounds. It also discusses the effects of future changes in engine fuel technology on PNA formation. The techniques involved in the collection of samples and in the separation and identification of constituents are included, as well as a summary of the areas in which more information is needed.

EF-6 (API Publ. 4005) -- The Effect of Fuel Volatility Variations on the Performance of Automobiles over a Range of Temperatures, April 1968

This report evaluates the low-temperature performance of automobiles and the extent to which such performance is a function of gasoline front-end volatility. It covers (1) the effect of reducing the front-end volatility on startup and warmup in current cars; (2) the minimum volatility for satisfactory startup and warmup performance over a wide temperature range; (3) the variation in performance for two groups of current cars, one with and one without emission control systems; and (4) the volatility limits which are imposed by normally encountered weaknesses of spark plugs, battery, and other engine components.

EF-6 (API Publ. 4022) -- Influence of Volatile Fuel Components on Vehicle Emissions, February 1970

The Bureau of Mines, in cooperation with API, studied the effects of fuel volatility and front-end fuel composition on photochemical reactivity of vehicle exhaust and evaporative emissions. In this study sixteen vehicles were operated on a climatic controlled dynamometer at ambient temperatures of 20°F, 45°F, 70°F and 95°F. A total of six gasolines was evaluated to determine the amount of hydrocarbon emissions and probable photochemical effect. Emissions of oxides of nitrogen, carbon monoxide, and aldehydes were determined.

EF-6 (API Publ. 4037) -- Comparative Emissions from Some Leaded and Prototype Lead-Free Automobile Fuels, May 1970

This project was studied experimentally by the U.S. Bureau of Mines in cooperation with API. Typical leaded gasolines and prototype lead-free gasolines of comparable octane quality were used in eight vehicles operated to simulate city driving. The experiments were run at 70° and 95°F. Exhaust and evaporative emissions were measured, and the photochemical effect of the emissions was experimentally observed in an artifical smog chamber. The results showed that the composition differences between the leaded and the prototype lead-free fuels lead to higher photochemical pollution potentials for the emissions from the lead-free fuels, owing to the photochemical characteristics of the high-octane fuel components that are used in greater quantity in the lead-free fuels. Graphs and tables.

EF-12 (API Publ. 4082) -- Use of Alcohol in Motor Gasoline ... A Review, August 1971

Prepared by API's Engineering and Technical Research Committee of the Committee for Air and Water Conservation, this review covers the history of alcohol blends in motor gasoline; the antiknock quality of alcohols; engine performance effects, including power and fuel economy, starting, warm-up, and vapor lock, and fuel system corrosion and wear (showing no advantages over conventional fuels, but some possible deleterious effects); alcohol-gasoline-water solubility; exhaust emissions of alcohol-gasoline blends (showing no advantage over conventional gasolines); and the unfavorable economics of alcohol-gasoline blends, including the cost of producing grain alcohol, the availability of grain for alcohol production, and new facilities for ethanol production from grain. Graphs, tables, and 36 references.

S-0 (API Publ. 4004) -- New York City's Air Pollution Problem -- Another Look, May 1967

This study was made to determine whether it is possible to predict and control air pollution episodes while minimizing the year-round use of high-cost, low-sulfur fuels. An analysis of the ambient air quality in New York City over the past several years has been made. The various sources of the so-called contaminants are identified and evaluated as to their effects on ambient air quality. Meteorological data has been analyzed to develop insight into the influence of weather conditions upon ground-level pollution concentrations. The results of these analyses are employed to indicate the approaches that will be most effective in improving air quality.

S-1 (API Publ. 4016) -- Mobilized Monitoring, June 1969

This was a two-year study designed to determine the ground level concentration of pollutants over an urban area. Mobilized monitoring was employed to determine the sulfur dioxide and particulate contents over a prescribed route covering the New York metropolitan area. The monitoring data was used in the development of an air pollution potential and warning system. The various meteorological parameters were also considered in the development of the multiple regression analysis program. Comparisons between the experimental and calculated results have been included in the report to demonstrate the validity of the regression analysis in predicting sulfur dioxide and particulate concentrations under varying conditions. The study is summarized in a packet containing two papers which were presented at the annual meeting of the Air Pollution Control Association in 1969.

S-2 (API Publ. 4000) -- Desulfurization Costs, Residual Fuel Oil -- Typical Caribbean Refinery, Venezuelan Crude Oil, February 1967

API sponsored this study to establish approximate costs and processing schemes for reducing the sulfur content of Caribbean residual fuel produced from Venezuelan crude oils. The report defines a typical Caribbean refining situation (base-case refinery) in terms of location, size, process units, product yield structure, crude oil charge, and product specifications. Various residual fuel oil sulfur specifications are imposed on this base-case refinery, and processing schemes and desulfurization costs are developed based on the required incremental additions to the base-case refinery. Proprietary information was made available to the contractor to develop feasibility and incremental costs of various desulfurization processes.

S-3 (API Publ. 4001) -- Expenditures for Fuel Products Desulfurization, April 1967

This report is the result of an API-sponsored research project on air conservation. It reports the results of a survey made of domestic petroleum refiners, major natural gas processors, independent process licensors, engineering contractors, and catalyst manufacturers, of past and present expenditures on research and development, facilities, etc., to reduce the sulfur content of fuels. Refinery sulfur balances and the sulfur content of crude oil and products are also given.

S-4 (API Publ. 4009) -- Engineering Study of Removal of Sulfur Oxides from Stack Gases, August 1968

This study presents an economic and technical evaluation of four major processes designed to remove sulfur oxides from flue gases.These processes -- dry dolomite (limestone) injection-wet scrubbing, catalytic oxidation, alkalized alumina and reinluft -- were selected after a careful screening of many control schemes. A necessary condition for process selection was that each should have the potential to reduce sulfur oxide emissions from coal or oil - fired power stations by 90 per cent or greater. Processes were evaluated and ranked by factors such as technical feasibility, state of development, process applicability, relative advantages, problem areas and economic considerations.

S-9 (API Publ. 4014) -- Study of Reactions of Sulfur in Stack Plumes -- First Annual Report, March 1969

This is a three-year research effort being co-sponsored by API, Bituminous Coal Research, Inc., Edison Electric Institute, and the National Air Pollution Control Administration (now part of the Environmental Protection Agency). The emphasis is directed to the physical and chemical reactions of sulfur compounds in fossil fuel combustion gases during and after release to the atmosphere. The construction of a pilot plant furnace is described in this report, together with the program for securing samples from the plumes of an oil— and coal— fired power plant. Laboratory studies designed to secure information on the kinetics of sulfur oxide reactions are also included in this report.

S-9 (API Publ. 4021) Study of Reactions of Sulfur in Stack Plumes -- Second Annual Report, December 1969

The first year of this study is covered in Publication 4014. During the second year, it was decided to supplement and emphasize the field flight program so that the statistical quality of plume measurements might be improved. The pilot plant combustion system previously operated with residual oil was adapted for pulverized coal during the second year program. Successful coal burning tests were carried out. Further experiments were performed in a reaction vessel in which quantum yields for SO_2 - O_2 mixtures over the range 10 to 100 per cent sulfur dioxide (SO_2) could be determined.

S-11 (API Publ. 4013) -- A Study of Sulfur Dioxide in Photochemical Smog -- First Annual Report, August 1968

This report discusses the results of the first year of a three-year study on the interaction of sulfur dioxide (SO_2) and photochemical smog. The extent of the interaction and its dependence on water vapor and the SO_2 level is discussed. In relatively dry systems, it was observed that SO_2 had a tendency to retard the photochemical reaction. In a similar manner, the levels of ozone were reduced over a given period of time.

S-11 (API Publ. 4019) -- A Study of Sulfur Dioxide in Photochemical Smog -- Second Annual Report, August 1969

The objective of this study was to determine the interaction of sulfur dioxide with photo-induced reactions involving hydrocarbons and nitrogen oxides. This is a report describing the work completed during the second year of a three-year program. In this report two possible mechanisms of sulfur dioxide (SO_2) reactions in photochemical smog are described. The effect of SO_2 on oxidant formation, as well as that of aerosols, is discussed in this report. By conducting irradiation chamber studies in the presence of Arizona road dust and flyash, the effect of particulates was also discussed.

S-12 (API Publ. 4008) -- An Evaluation of Residual Fuel Oil Sulfur Determinations, March 1968

With the increased emphasis on sulfur in residual fuel oil, the importance of the reproducibility and repeatability of analyses became evident. A cooperative program in which 24 laboratories participated was initiated by API. This report contains the results of this survey on residual fuel oil samples containing 2.0 to 2.2 per cent sulfur. The standard ASTM methods were used, and a statistical analysis of the data was completed to indicate the variance that could be expected.

S-12 (API Publ. 4018) -- An Evaluation of Methods for Determining Sulfur in Fuel Oils, August 1969

This study was sponsored by API to develop a better understanding of the variability in fuel oil sulfur determinations. An earlier report by the same investigators discussed the relationship between test methods and precision with fuel oils having sulfur contents in the range of 1 per cent to 2 per cent. In this study four samples of distillate fuel oil having sulfur contents ranging from 0.2 percent to 0.5 per cent were tested, as well as eight samples of residual fuel oil . The residual fuel oil sulfur content ranged from 0.2 per cent to 1. 4 percent. Six test methods were evaluated to indicate their precision and accuracy in determining the sulfur content of these fuel oils.

S-13 (API Publ. 4079)--Adsorption of Sulfur Dioxide on Particulate Surfaces, July 1971

An experimental study conducted by the University of North Carolina School on Public Health for API on the adsorption of sulfur dioxide (SO_2) on a variety of particulate surfaces in the presence of other common gaseous contaminants was carried out with SO_2 labelled with sulfur-35 in a closed-circuit fluidized bed. The presence of carbon monoxide and 1-butene increased the adsorption of SO_2 on all surfaces tested except glass. The adsorption of SO_2 always increased as the concentration of sulfur dioxide in the gas phase increased and with the surface area of the substrate. Attempts to desorb SO_2 from the particle surface either by heating or by reducing the partial pressure of SO_2 were unsuccessful. Sulfur dioxide adsorption on particulates is apparently not a biologically significant factor. A man breathing a concentration of ppm sulfur dioxide would inhale ~15 mililiters (ml) or 40 miligrams (mg) of sulfur dioxide in 24 hours of which only 400 micrograms (ug) would reach the lower lungs; 9 ug more might reach the lungs in the presence of a heavy loading (1mg/cu m) of an inert dust. Tables, graphs, and diagram.

SS-5 (API Publ. 4099)--A Field Investigation of Emissions from Fuel Oil Combustion for Space Heating. (Battelle Memorial Institute)

BR-6 (API Publ. 4020)--An Evaluation of Dispersion Formulas, October 1969

This report is intended as a guide to petroleum industry personnel in making computations and decisions involving atmospheric emissions. The report will provide general and specific guidance on the use of the formulas together with comments on the realistic application of such formulas. It is suggested the 1968 ASME Guide or the Public Health Service Publication 999-AP-26 be used in conjunction with this report. The report provides comments and analysis on short-term concentrations, point and line sources, long-term average of the surrounding atmosphere at a point source, stack emissions and mathematical models for area and multiple sources.

BR-8 (API Publ. 4007)--Sources, Abundance, and Fate of Gaseous Atmospheric Pollutants, February 1968

This analysis of the sources, abundance, and fate of gaseous atmospheric pollutants considers three families of compounds -- sulfurous, nitrogenous , and organic; and two inorganic carbon compounds -- carbon monoxide and carbon dioxide (CO_2). With the exception of CO_2, similar analytical patterns have been used for these materials and have produced rather detailed analyses. The presentation of CO_2 is a brief review of current thinking. Estimates of annual worldwide emissions of pollutants -- SO_2, H_2S, CO, NO_2, NH_2, and organics -- are included. The magnitudes of the natural emanations of a variety of materials are also considered.

BR-8 (API Publ. 4015)--Sources, Abundance, and Fate of Gaseous Atmospheric Pollutants, Supplemental Report, June 1969

This report is a supplement to a comprehensive report published by the same authors in 1968 examining the present state of knowledge of the atmospheric cycles of a number of common gaseous air pollutants. Since several questions remained unanswered because of available time, the present report contains a more detailed analysis of the atmospheric buildup of carbon dioxide (CO_2). The more recent data on the question of carbon monoxide (CO) concentrations in the atmosphere is considered in this report, together with the cycle of nitrogen products. The differences between the northern and southern hemispheres as well as the scavenging mechanisms that exist in the natural environment for all the gaseous pollutants are discussed. The bearing these scavenging mechanisms may have on long-term accumulations of pollutants in the atmosphere is also reviewed in this report.

BR-8 (API Publ. 4076) - Emissions, Concentrations, and Fate of Particulate Atmospheric Pollutants, March 1971

An integrated analysis of atmospheric aerosols (up to about 10 dia) from pollutant and natural sources, their emission rates, physical characteristics, scavenging processes, and geophysical implications was made on the basis of available world-wide data for 1966-68. The total particulate emission from both sources was found to be about 2.6 billion tons per year; about 11 percent of this comes from atmospheric pollutants. A summary of naturally formed particulate emissions (in million tons/yr.) shows that sulfate aerosols formed from hydrogen sulfide total 204; nitrate aerosols from oxides of nitrogen (NO_x), 432; ammonium aerosols from ammonia, 269; and photochemical aerosols from terpenes and other volatile organic materials, 200. Particulate pollutants total 92 million tons/yr; petroleum refining and the combustion of petroleum products contribute about 3 percent of this, and other combustion operations account for 13 percent. Particles formed from gaseous pollutants include sulfate aerosols from sulfur dioxide emissions (147 million tons/yr); nitrate aerosols from NO_x (30 million tons/yr); and photochemical aerosols from emissions of reactive hydrocarbons (27 million tons/yr). Tables, graphs, chart, maps, and 93 references.

BR-10 (API Publ. 4010) - Report on Air and Water Conservation Expenditures of the Petroleum Industry in the United States, August 1968

This report contains data on 1966 and 1967 pollution control expenditures by companies processing 97 percent of all crude oil refined in the United States. Projected expenditures for 1968 are also included. Expenditures are divided into four major categories: capital, operating and maintenance, administrative, and research and development. In addition, the air conservation expenditures section contains details on the amount spent on seven contaminant types as well as on vehicle emissions.

BR-10 (API Publ. 4075) -- Report on Air and Water Conservation Expenditures of the Petroleum Industry in the United States (IN) 1966-1970, February 1970

Surveys conducted by the API Committee for Air and Water Conservation, based on replies to questionnaires by 45 oil companies (representing 98.3 per cent of the industry's crude oil charge per calendar day), show that, during the five-year period, the petroleum industry spent over $2 billion for these purposes. Total expenditures increased by about 20 per cent per year in the five-year period. The capital outlay accounted for over 60 per cent of the total expenditures, or $1.23 billion. Operating and maintenance costs for conservation equipment totaled $518 million and rose by an average of $11 million per year; about 60 per cent of this increase was for water conservation. The cost of administering the conservation program totaled $147.6 million for the five years; research and development required over $150 million, of which 25.1 per cent went for hydrocarbons control, 37.3 per cent for sulfur oxides, 12.2 per cent for particulates, and the remainder for carbon monoxide, nitrogen oxides, and other air contaminants. The survey data are tabulated and analyzed in detail. Graphs.

W-3 (API Publ. 4083)--The Impact of Oily Materials on Activated Sludge Systems, March 1971

A report by Hydroscience, Inc. for API and the U. S. Environmental Protection Agency on small scale continuous activated sludge sewage treatment systems exposed to used crankcase oil, vegetable oil , refinery waste oil, or to crude oil showed that oils introduced into an activated sludge system are absorbed on the floc and slowly degrade. If the loading rate was higher than the degradation rate and the rate of wastage, the oil accumulated on the sludge, causing a loss of density and of acceptable settling characteristics. The biological system fails because of the loss of sludge, but the ability of the microbial system to oxidize organic wastes was not inhibited. Except for highly emulsified systems, all necessary oil separation could be achieved by aeration and flotation; these features can be incorporated in the grit chamber/settling tank designs of most plants. Diagrams, graphs, tables, and 18 references.

W-4 (API Publ. 4011)--Domestic Refinery Effluent Profile, September 1968

This survey of the petroleum industry was completed in 1967 and obtained information on the waste water treatment and control practices as well as final effluent quality. The response to this questionnaire was equivalent to 93 percent of the domestic crude refinery capacity. The data on 171 refineries are given by size as well as refinery complexity. The complexity groupings range from simple topping plants to more sophisticated operations including catalytic cracking as well as lubricating oil and petrochemical processing.

W-5 (API Publ. 4041)--Industrial Oily Waste Control, July 1970

A collection of articles entitled "Industry's Oily Waste Problem," "Glossary," "Standards for Effective Oily Waste Control" "Defining the Oily Waste Control Problem," "Control of Oily Waste at the Source," "Oily Wastewater Treatment," "Disposal of Oily Wastes," "Typical Oily Waste Control Operations," and "Oily Waste Control Management." Photographs, flow diagrams, diagrams, charts, tables, graphs, and numerous references.

W-6 (API Publ. 4012)-- A Primer on Oil Spill Cleanup, December 1968

Methods and materials for dealing with spills are explained, leaving to the man on the scene the choice as to which of these will work best in his circumstances. Factors that will influence these choices include type of petroleum products handled, amount of oil, water currents, wind, weather, equipment available and special considerations, such as closeness to drinking water intakes, fishing grounds, wildlife habitats, and bathing beaches or recreational areas. Four basic steps involved in dealing with an oil spill involve limiting the spill, containing the spill, removal of oil from the water, and final cleanup. This booklet is organized in sections dealing with each of these steps in turn. Some general facts about oil spills precede these sections.

W-7 (API Publ. 4036)--Final Report of the API...Task Force on Used (Automotive) Oil Disposal, August 1970

An intensive study, including commercial-scale burning tests, indicates that used lubricating oils should be blended with residual fuel oil and burned. This method usually permits heat recovery and utilization. Burning may be done with or without prior treatment to reduce water and sediment content. The blend composition, preferably, should consist of no more than 25 percent used lubricating oil to minimize combustion difficulties and to avoid air pollution problems. Contracting for used oil disposal for existing rerefining services and/or scavenger pick-up services should be continued. Oil companies should strive to assist service stations to assure that used oils are always disposed of in a nonpolluting manner. API can and should serve as a clearinghouse for information on used oil disposal, and, in cooperation with state petroleum councils, should provide support for state legislation concerning used oil disposal. Diagrams, graphs, and tables.

L-11 (API Publ. 4035)--ACS Air Quality and Lead, April 1969 (Symposium of the American Chemical Society).

Prominent current interest in the authoritative present-day research on lead in the environment with specific references to air quality, presence in the soil, and associated distribution in vegetation and animals prompted the sponsorship of this symposium by the Division of Industrial and Engineering Chemistry, with the Division of Water, Air and Waste and of Petroleum Chemistry as co-sponsors. Eight of the papers presented pertain to recent experimental research. The two remaining papers are critical reviews of the literature.

OS-1 (API Publ. 4024, 4025)-- Systems Study of Oil Spill Cleanup Procedures -- (1) Analysis of Oil Spills and Control Materials (2) Industry Response Plan, February 1970

A report prepared by Dillingham Corp. for API includes, in Volume I, an analysis of past oil spills and a definition of the problem created by a massive oil spill in open water; a study of oil spill control equipment and methods; and identifications of control materials that are currently available and appear most promising; and, in Volume 2, a proposed industry response plan, including a detailed description of the organization and procedures recommended to support and actuate an oil-spill cleanup system utilizing the materials identified in the earlier phases of this study, and some guidelines which may be adapted to the particular requirements of any organization or regional group preparing to respond to the threat of a major oil spill. Maps, diagrams, charts, graphs, tables, and 59 references.

OS-6 (API Publ. 4042)-- Oil Spill Treating Agents...A Compendium, May 1970

Prepared by Battelle-Northwest for the API Committee for Air and Water Conservation, this compendium includes data sheets for dispersants, sinking agents, sorbents, combustion promoters, biological degrading agents, gelling agents, beach cleaners, and miscellaneous agents. Descriptions of effectiveness test procedures and marine toxicity tests for these agents are appended. Eleven references.

OS-7 (API Publ. 4053) -- Oil Spill Treating Agents...Test Procedures: Status and Recommendations, May 1970

A report prepared by Battelle-Northwest for the API Committee for Air and Water Conservation covers the applicability of established standard test methods to oil-spill treating agents; evaluation of effectiveness tests for dispersants, sinking agents, sorbents, combustion promoters, biological degrading agents, gelling agents, and beach cleaners; and toxicity measurement. Diagrams, chart, graphs, tables, and 85 references.

OS-8 (API Publ. 4068)--Oil Spill Treating Agents...Selection Based on Environmental Factors, October 1970

A survey was carried out by Arthur D. Little, Inc. for API to establish a cross section of the environmental characteristics that are representative of conditions along the U. S. coastlines and inland waterways, to determine which characteristics are important, how they influence the selection of oil-spill treating agents and treating techniques, and how the treatments may affect the environment. To assist in the formation of all oil-spill contingency plans, the report also indicates the classes of treating agents that are likely to be most useful in each of several typical environments and points out the interactions that are likely to make some of them undesirable or impractical. Graphs, tables, diagram, and 43 references.

OS-10 (API Publ. 4023)--American Petroleum Institute Oil Spill Control Survey for Onshore and Offshore Facilities, March 1970

During 1969, a petroleum industry task force conducted a questionnaire survey to obtain information on all domestic oil facilities having water on one or more border. The primary objective of this survey was to secure sufficient information to allow the petroleum industry to proceed with the development of orderly response programs for oil spill prevention and cleanup. Information was obtained on the location of the facilities and projects stored and the present individual capabilities for participating in an oil clean-up program. Moreover, data on surrounding oil-handling facilities operated by API member companies as well as non-petroleum companies, were obtained to make a complete evaluation of the existing conditions. The status of existing cooperatives and independent cleanup services in each area was determined. Sample questionnaire, maps, and tables.

CAPE-2-68 (API Publ. 4056)--Effects of Gasoline Additives on Carburetor and PCV System Performance as they Relate to Exhaust Emissions...First Year Report, April 1970

In a study carried out by Scott Research Laboratories, Inc. for the National Air Pollution Control Administration (now part of the Environmental Protection Agency) and the Coordinating Research Council, Inc., three groups of 16 cars each (all using the same base fuel, but two groups having fuel additives) are being driven in normal urban and suburban modes of operation for 24,000 miles under controlled fuel conditions and maintenance. During the first year, exhaust emission measurements were made at the start of the test and at 4,000-mile intervals. An analysis of variance was conducted on each of 19 emission parameters for the zero and 4,000-mile interval. A major conclusion was that no significant difference in emission parameters was observable at the 4,000-mile point on the basis of the fuel employed. In addition, all emission parameters vary significantly between automobile makes; however, no single make is consistently the highest or lowest valued across the spectrum of the 19 emissions parameters measured. Graphs and tables.

CAPE-5-68 (API Publ. 4066, 4067)--A Survey of Typical Driving Patterns of the Los Angeles Metropolitan Area Relative to Auto Air Pollution -- 1, 2, July 1968

This survey was conducted by the 3-M Co. for the Coordinating Research Council, Inc. By personal and telephone interviews and driver-monitored trips, data on the frequency and characteristics of vehicular use in 24 hours in the area were gathered and analyzed to determine typical driving patterns. The procedures followed during the survey are described, and all the data obtained in the study are presented in graphic or tabular form. Tables, flow charts, data forms, printouts, histograms, and maps.

CAPE-5-68 (API Publ. 4063)--The Time-Temperature Histories of Specified Fuel Systems (Vol. I), October 1969

Specified fuel systems were studied by Scott Research Laboratories, Inc. in summer 1968 in Los Angeles County under contract with the Coordinating Research Council, Inc.

The 80 cars studied were instrumented to measure 16 fuel system temperatures and pressures, and were operated over three test patterns to characterize the time-temperature profiles of the fuel system components during trip segment and soak periods. Results showed that a pattern with several short daily trips caused the highest fuel tank and carburetor maximum temperatures, "to and from work" patterns on a freeway the next highest maxima, and a business-residential route the lowest maximum temperatures. On an over-all pattern basis, ambient temperature is the dominant source of variance in fuel tank liquid temperatures, but vehicle-to-vehicle variance is the dominant source for carburetor fuel bowl temperature maxima. The data presented in this report should aid in the development of realistic test procedures for measuring fuel evaporative emissions, and also provide a basis for predicting these emissions from the total vehicle population with the aid of mathematical models. Tables, graphs, diagrams, forms, maps, and photographs.

CAPE-7-68 (API Publ. 4044)--Chemical Species in Engine Exhaust and Their Contribution to Exhaust Odor, June 1969

Specialized high-resolution gas chromatographic techniques, including a dual column system, were developed to separate and detect the components in diesel exhaust that produce odor. About 50 out of 1,000-2,000 compounds present were strongly odor-relevant; they were encountered throughout the boiling range studied (30°-260°C). About ten (probably aldehydic compounds, with most likely one or two double bonds and possibly including some branched chain configuration) were very strongly odor-relevant, possessing strong odors at low concentrations. Chromatograms, photographs, diagrams, tables, and graphs.

CAPE-7-68 (API Publ. 4045)--The Chemical Identification of the Odor Components in Diesel Engine Exhaust, July 1969

Arthur D. Little, Inc. carried out this study for the Coordinating Research Council, Inc. and U. S. National Air Pollution Control Administration (now part of the Environmental Protection Agency). The odor components of diesel engine exhaust are first concentrated and then separated to permit their identification by high-resolution mass spectrometry. The system developed (silica liquid column chromatography followed by silicone and carbowax gas chromatography), combined with monitoring the efl1uent components by odor as well as by instruments, demonstrates the variety of odor types and the complexity of the chemical mixture involved in diesel exhaust. Several individual components with odors relating to the burnt-odor complex are recognizable, and in some cases are present in sufficient concentration to permit identification, particularly with regard to the lower-boiling fractions. Charts, graphs, chromatograms, and tables.

CAPE-7-68 (API Publ. 4061)--Chemical Identification of the Odor Components in Diesel Engine Exhaust...Final Report (Year 2), June 1970

During the second year of a study being carried out by Arthur D. Little, Inc. for the National Air Pollution Control Administration (now under the Environmental Protection Agency) and the Coordinating Research Council, Inc., the two-stage gas chromatographic (GC) method for resolving the odor fractions was refined by use of a GC fraction-trapping method and was applied with great success to the oily-kerosine odor fraction obtained from the first-stage liquid-column chromatography separation. The odors of the individually resolved compounds were characterized, and their chemical structures were determined by high-resolution mass spectrometry. The chemical classes associated with the odor in the oily-kerosine portion of diesel-exhaust odor were found to be alkylbenzenes, indans/tetralins, and indenes. Alkylnaphthalenes constitute a major portion of the mass of the oily-kerosine fraction but are not a major odor contributor. The unburned fuel probably contributes heavily to the oily-kerosine odor. Analytical work to date on the smoky-burnt odor fraction is also reported briefly. Charts, tables, chromatogram, and graphs.

CAPE-7-68 (API Publ. 4069)--An Analysis of Los Angeles Atmospheric Reaction Data From 1968 and 1969, July 1970

Obtained by Scott Research Laboratories, Inc., National Air Pollution Control Administration (now under the Environmental Protection Agency), and the Coordinating Research Council, Inc., the project has identified some of the significant photochemical aspects of the air-pollution control problem. Mole-weighted averages place the hydrocarbon mixture between ethylene and 1-alkenes on a biological-effects response scale. Curves for peak hourly oxidant show that more stringent control is needed for oxides of nitrogen (NO_x) than for nonmethane hydrocarbosn (NMHC) to achieve a given oxidant standard. NMHC-NO_x ratios less than 1:1 appear to avoid optimum oxidant production. The emission source proportions of NO_x-to-inerts (such as carbon monoxide and acetylene) are not reflected in morning air samples on high oxidant days. Tests using the 1969 data indicate a breakdown of the quasi-equilibrium assumption for the NO_x-ozone cycle as ozone concentration differs from zero. The analysis also includes data from aerial surveys that may prove useful for mathematical modeling studies. Tables, graphs, maps, and 33 references.

CAPE-7-68 (API Publ. 4098)--Chemical Species in (Diesel) Engine Exhaust and Their Contribution to Exhaust Odors, November 1970

These were studies by the Illinois Institute of Technology Research Institute for the National Air Pollution Control Administration and the Coordinating Research Council, Inc. by use of high-resolution two-column gas chromatography, mass spectrometry, and sensory observations. Solid adsorbent collection devices were used to obtain samples from a nitrogen-diluted exhaust stream. Of the hundreds of compounds present, only a small fraction exhibited distinct odors at concentrations encountered in the exhaust. The major concentration species, the paraffinic hydrocarbons, are individually nonodorous. The odor-relevant species are polar, and many exhibit low odor thresholds. The more important odor contributors include aliphatic aldehydes; aliphatic compounds with more than one position of unsaturation; alkyl derivatives of benzene, indan, tetralin, and naphthalene; aldehyde and ketone derivatives of benzene and alkylbenzenes; and sulfur species. Auxiliary gas-chromatographic methods suggest that aliphatic acids are also odor-relevant. Diagrams, graphs, and tables.

CAPE-7-68 (API Publ. 4100)--Chemical Identification of the Odor Components in Diesel Engine Exhaust.

CAPE-8-68 (API Publ. 4078)--The Kinetics of Oxidation and Quenching of Combustibles in Exhaust Systems of Gasoline Engines, 1970

These are being studied at the University of Michigan for the Coordinating Research Council, Inc. This progress report of work done in the one-year period from early 1969 covers the results of performance and emission analyses of an engine-mounted DuPont type V thermal exhaust reactor at 1200 revolutions per minute, with Indolene fuels at various air-fuel ratios, spark timings, engine speeds, and loads; the design of an experimental stirred-tank (two-tank) reactor, which will operate at up to 60 lb-mass/hr and will provide kinetic data for a perfectly mixed system; the results of a linear reactor study of exhaust gas; the development of a first-generation model based on the instantaneous mixing of air and exhaust at the reactor inlet, to simulate the operation of the engine-mounted reactor by use of rate data from the experimental two-tank reactor; and the results of a feasibility study of the use of a spectroscope for analyzing engine exhaust (compared with the use of a nondispersive IR analyzer) and the use of a subtractive column analyzer to measure the paraffins, aromatics, and olefins contents. Tables, diagrams, photographs, graphs, spectra, and 57 references.

CAPE-9-68 (API Publ. 4062)--An Investigation of Passenger Car Refueling Losses, March 1970

Losses in the form of displaced fuel tank vapors, liquid spills, and nozzle drippage was conducted by Scott Research Laboratories, Inc. for the Coordinating Research Council Inc. and the National Air Pollution Control Administration.

It involved a pilot test program to identify and measure hydrocarbon losses during refueling at service stations at ambient temperatures (45°, 60°, 75°, and 90°F). The test gasoline had a 7.2-9.8 Rvp average. A field survey showed that, for a total of 690 observations, the over-all frequency of overfill/spitback was 26.1%; that of prefill nozzle losses, 8.6%; and that of post-fill nozzle losses, 34.2%. Significant factors contributing to individual and over-all refueling losses are examined and discussed. Diagrams, forms, photographs, tables, and graphs.

CAPE-10-68 (API Publ. 4034)--A Survey of Average Driving Patterns in the Chicago Urban Area, November 1969

The survey was made by System Development Corp. under contract to the National Center for Air Pollution Control and the Coordinating Research Council, Inc., to obtain the data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices. The procedures and results here discussed in detail and compared with those for Los Angeles, Boston, and Cincinnati. Map, graphs, and tables.

CAPE-10-68 (API Publ. 4046)--A Survey of Average Driving Patterns in the Los Angeles Urban Area, February 1969

This survey was made by System Development Corp. for the Coordinating Research Council, Inc. to obtain the data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices. During the study, automatic information recording devices (Tachographs) were installed in 199 private automobiles. These data records, together with the volunteer drivers' log books, were analyzed to obtain typical driving patterns for two-, three-, four-, and five-trip days. These results, as well as the survey techniques and data reduction and anlysis procedures, are presented and discussed in detail. Graphs and tables.

CAPE-10-68 (API Publ. 4084)--A Survey of Average Driving Patterns in the Houston Urban Area, August 1969

This survey was made by System Development Corp. under contracts with the National Center for Air Pollution Control and the Coordinating Research Council, Inc., to obtain the data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices. Tachographs were installed in 99 private automobiles, and these data records, as well as the volunteer drivers' log books, were analyzed to obtain typical driving patterns for two-, three-, four-, and five-trip days. The results of the study are discussed in detail and compared with those obtained in a similar survey conducted in Los Angeles, as part of an effort to obtain nationally valid conclusions concerning driving patterns. Map, table, and graphs.

CAPE-10-68 (API Publ. 4085)--A Survey of Average Driving Patterns in the Minneapolis-St. Paul Urban Area, February 1970

This survey was made by System Development Corp. under contracts with the National Center for Air Pollution Control and the Coordinating Research Council Inc., to obtain the data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices. Tachographs were installed in 125 private automobiles, and these data records, together with the volunteer drivers' log books, were analyzed to obtain typical driving patterns for two-, three-, four-, and five-trip days. A comparison of the results with those obtained in previous surveys in Chicago (Abstract No. 18-31176), Cincinnati, Houston, and Los Angeles showed striking similarities. The data and their statistical significance are described in some detail. Map, Graphs, and tables.

CAPE-10-68 (API Publ. 4086)--A Survey of Average Driving Patterns in the Cincinnati Urban Area, September 1969

This survey was made by System Development Corp. under contracts with the U. S. National Center for Air Pollution Control and the Coordinating Research Council, Inc., to obtain the data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices. Tachographs were installed in 149 private automobiles, and these data records, together with the volunteer drivers' log books, were analyzed to obtain typical driving patterns for two-, three-, four-, and five-trip days. The results showed striking similarities to patterns obtained in earlier surveys in Los Angeles and Houston. The data and their statistical significance are discussed in detail. Map, graphs, and tables.

CAPE-10-68 (API Publ. 4087)--A Survey of Average Driving Patterns in the New York Urban Area, August 1970

This survey was made by System Development Corp. for the Coordinating Research Council, Inc. to obtain the data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices. During the study, automatic information recording devices (tachographs) were installed in 289 privately operated automobiles. These data records, together with the volunteer drivers' log books, were analyzed to obtain typical driving patterns for two-, three-, four-, and five-trip days. A detailed comparison of the results with those obtained in previous surveys in Los Angeles (Publ. 4046), Houston (Publ. 4084), Cincinnati (Publ. 4086), Chicago (Publ. 4034), Minneapolis-St. Paul (Publ. 4085), and New York is presented. Graphs, tables, and map.

CAPE-10-68 (API Publ. 4088)--A Survey of Average Driving Patterns in Six Urban Areas of the United States: Summary Report, January 1971

An analysis of the findings of surveys carried out by System Development Corp. for the Coordinating Research Council Inc. in Chicago, Los Angeles, Houston, Cincinnati, Minneapolis-St. Paul, and New York (API Publ. 4034, 4046, 4084, 4086, 4085 4087) shows that, although there appear to be significant differences in the automobile utilization and trip descriptions in the six cities, the individual and composite distributions of the various statistics indicate that there are many similarities. There were six typical daily driving patterns that stood out clearly. The distribution of these daily patterns was quite similar among Houston, Cincinnati, Chicago, and Minneapolis-St. Paul, but New York differed in having more zero-trip days, and Los Angeles had more multiple-trip days. The similarities and differences in daily patterns for each city are discussed in detail. Graphs and tables.

CAPE-10-68 (API Publ. 4089)--A Survey of Average Driving Patterns in the Los Angeles Urban Area Based Upon Data Obtained in a Telephone Survey, December 1970

A reanalysis of the data base gathered by the Three-M Co. during a survey of typical driving patterns in the Los Angeles metropolitan area (Publ. 4066, 4067) was carried out by System Development Corp. (SDC) for the Coordinating Research Council, Inc. to put the data in a format comparable to SDC's similar report on typical Los Angeles driving patterns (Publ. 4046). The telephone data base consisted of 2464 trips (1773 weekday and 691 weekend trips). In spite of difficulties in making comparisons between the two sets of data, the reanalysis showed that the patterns previously established by SDC as typical are present in the telephone survey, but no new patterns are shown. The telephone technique is a valuable means of determining daily use patterns but has questionable merit for determining quantitative trip descriptive parameters. Monitor trips carried out to validate the telephone data gave results that compared reasonably well with SDC's data but showed many inconsistencies with the phone survey data. Graphs and tables.

CAPE-11-68 (API Publ. 4071)--Oxygenates in Automotive Exhaust Gas -- 3. Carbonyls and noncarbonyls in Exhausts from Simple Hydrocarbon Fuels, November 1970

Simple hydrocarbon fuels can be analyzed by procedures developed by the U. S. Bureau of Mines, Bartlesville Petroleum Research Center, under contract with the Coordinating Research Council, Inc. The procedures involved the concentration of the exhaust organics followed by a two-stage gas chromatographic separation of the resultant mixture of oxygenates and hydrocarbons. Separated oxygenates were identified by use of mass spectrometry and/or gas chromatography retention times. Identified oxygenates in exhausts from nine test fuels included saturated and unsaturated aldehydes, ketones, alcohols, ethers, esters, and nitroalkanes; phenols and nitromethane appear to be relatively the most abundant of the noncarbonyl oxygenates. Procedures were also developed for the detailed analysis of gasoline exhaust carbonyls through intermediate conversion to carbonyl oxime derivatives, with subsequent isolation and chromatographic analysis of the oxime mixture. Tables, diagrams, and chromatograms.

CAPE-11-68 (API Publ. 4090)--Improved Instrumentation for Determination of Exhaust-Gas Oxygenate Content... Annual Report, March 1970

An experimental study carried out by Scientific Research Instruments Corp. for the U. S. National Air Pollution Control Administration showed that the chemical ionization direct-reading mass spectrometer can be used to monitor individual saturated aldehydes and ketones in automobile engine exhaust at concentrations of 10 ppb to 300 ppm. The design and operation of the spectrometer are described in detail. Photographs, diagrams, spectra, tables, and 37 references.

CAPE-12-68 (API Publ. 4039)--Final Summary Technical Report on the Physical-Chemical Characteristics of Particles Associated with Polynuclear Aromatic Hydrocarbons Present in (Spark-Ignition)Automobile Exhaust to Coordinating Research Council, Inc. January 1970

Analyses were performed by Batelle Memorial Institute on single particles or aggregates and on particle-size fractions separated with the Battelle cascade impactor, Definitions of particle morphology and inorganic compositions were possible with the transmission electron microscope and electron probe, respectively. Lead was the metal constituent in the most prevalent smaller particles, and calcium and iron were primarily contained in larger particles. Compositional variations among the impactor size-fractions were not found to correlate with the distribution of the carcinogen benzo(a)pyrene, which was detected in each impactor fraction analyzed. Electron micrographs, photomicrographs, photographs, diagrams, tables, and graphs.

CAPE-12-68 (API Publ. 4074)--The First Annual Report on Gasoline Composition and Vehicle Exhaust Gas Polynuclear Aromatic Hydrocarbon (PNA) Content, February 1970

This comprises the preliminary results of work done by Esso Research & Engineering Co. for the Coordinating Research Council, Inc. and the National Air Pollution Control Administration. In cyclic tests conducted on a chassis dynamometer with a car having no emission controls (NC) and a car having engine-modification controls (EM), the observed emission rates per gal. of fuel burned were 116-689 mg of phenols, 26-149 micrograms (ug) of benzo(a)pyrene(BaP), and 54-303 ug of benz(a) anthracene(BaA). Phenol emission from the EM car was not significantly lower than from the NC car with 46 percent aromatic fuels, but was 8-30 per cent lower with the 12 per cent aromatic fuels. In the NC car, the presence of lead-free engine deposits increased phenol emission by 14-35 per cent above the no-deposit results, and conversion to leaded deposits produced a further increase of 21-38 per cent. Increasing fuel aromaticity from 12 per cent to 46 per cent increased PNA emission by 36-74 per cent in the NC car, but only by 8-34 per cent in the EM car. The addition of lead to both combustion-chamber deposits and fuels, after adjustment for carbon monoxide-emission differences, increased BaP emissions by 95 per cent and BaA emissions by 120 per cent. Tables, diagrams, photographs, graphs, flowsheet, and 18 references.

CAPE-12-68 (API Publ. 4072)-- First Annual Report: Progress in Development of Rapid Methods of Analysis for Trace Quantities of Polynuclear Aromatic Hydrocarbons (PNA) in Automobile Exhaust (Tar and Gasoline) February 1970.

The method, developed by Esso Research & Engineering Co. for the Coordinating Research Council, Inc. and the Air Pollution Research Advisory Committee involves a preliminary separation of PNA by liquid-solid adsorption column chromatography; specific compounds are then measured by combined gas chromatography - UV adsorption spectrophotometry (GC/UV), which employs an internal standard. For gasoline samples, repeatability for benz(a)anthracene (BaA) and benzo(a)pyrene (BaP) was 1-12 per cent relative. BaP results agreed well with measurements by a more classical method, but BaA values by the GC/UV method were systematically lower. A preliminary study indicated that measurement of BaA by the GC/UV method is more nearly correct. Analysis of four automobile-exhaust tar samples also gave lower BaA values by the GC/UV method than those from the classical method. Complete details of the method are appended. Tables, graphs, flow chart, spectra, and diagram.

CAPE-13-68 (API Publ. 4101)-- The Economic Effectiveness of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emissions, Vol. I

CAPE-13-68 (API Publ. 4102)--The Economic Effectiveness of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emissions, Vol. III.

CAPE-13-68 (API Publ. 4103)--Vehicle Emissions Surveillance Study

CAPA-2-68 (API Publ. 4064)--Economic Impact of Air Pollutants on Plants... Annual Report...Vol. 1, August 1970.

A study being carried out for the Coordinating Research Council, Inc. by Stanford Research Institute indicates that crop losses caused by ozone, peroxyacetyl nitrate, and nitrogen dioxide total about $65,000,000 for the U.S. each year; approximately $3,500,000 is lost due to sulfur dioxide; and $3,000,000 due to fluorides, excluding losses to residential or home plantings. These pollutants account for approximately 90 per cent of the damage to vegetation caused by air pollutants. Tables, maps, and 13 references.

CAPA-2-68 (API Publ. 4070)-- Economic Impact of Air Pollutants on Plants... Annual Report... Vol. 2, November 1970

This volume of a report prepared by the Stanford Research Institute for the Coordinating Research Council, Inc. includes the estimated crop losses due to ozone, peroxyacetylnitrate, and oxides of nitrogen for 68 crops that are sensitive to these air pollutants. Information is presented for 525 U.S. counties in which the level of air pollution was considered to be high enough to cause significant crop losses. Tables, See also Abstract No. 18-30562

CAPA-3-68 (API Publ. 4065)--A Practical, Multipurpose Urban Diffusion Model for Carbon Monoxide...Final Report. September 1970.

In a study carried out by Stanford Research Institute for the Coordinating Research Council Inc. and the National Air Pollution Control Administration, a receptor-oriented diffusion model was developed, which gives carbon monoxide concentration isopieths for a given set of meteorological conditions and time of day, sequences of hourly carbon monoxide concentrations at specific locations for given sequences of meteorological conditions, and climatological summaries of carbon monoxide concentration for specific locations if a historical record of meteorological data is available. The model can be used to obtain the frequencey distributions of concentrations averaged over various time intervals for specific hours of the day or days of the week. The model inputs are traffic volumes on major streets and highways in the urban area, atmospheric stability, mixing depth, and wind speed and direction. Carbon monoxide concentrations given by the model are generally lower than observations from Continuous Air Monitoring Program stations, but can be improved by empirical corrections. Photographs, diagrams, charts, graphs, tables, maps, and 65 references.

CAPA-3-68 (API Publ. 4092)--A Field Study for the Initial Evaluation of an Urban Diffusion Model for Carbon Monoxide, June 1971

This study, developed by Stanford Research Institute for the Coordinating Research Council, Inc, and U.S. Environmental Protection Agency, was made in San Jose, Calif. in Nove.-Dec. 1970. Seven stations were operated in two-block downtown area to measure carbon monoxide at five heights, winds, and temperature gradients. Carbon monoxide concentrations and temperatures were also measured by helicopter and two vans. A new street-effects submodel was developed. The revised model reproduces the observed frequency distributions very well for street-canyon sites. Hourly predictions are well correlated with observations(correlation coefficient of about 0.6 to 0.7), with a level of uncertainty only half that with the unrevised model. Photographs, maps, diagrams,graphs, charts, tables, and 28 references.

CAPA-4-68 (API Publ. 4057)--The Biosphere as a Possible Sink for Carbon Monoxide Emitted to the Atmosphere (By Various Human Activities)... A Final Report, May 1970

Stanford Research Institue prepared this report for the National Air Pollution Control Administration and the Coordinating Research Council Inc., tests involving the exposure of test samples to 100 parts per million(ppm) carbon monoxide indicate that microorganisms in the biosphere can serve as a carbon monoxide sink. Nonsterile soil depleted carbon monoxide rapidly from test atmospheres containing initial concentrations of 100 ppm carbon monoxide. This effect was enhanced by increasing temperatures and eliminated by steam sterilization, indicating that heat-labile biological mechanisms were involved. The minimal experimental depletion rates demonstrated theoretically could account for 2.06 x 10^{15}grams per year of carbon monoxide on a world-wide basis. Moistened vermiculite also depleted the same carbon monoxide at 19.5°C but not at 10°C. Chart, graphs, tables, and 12 references.

CAPA-6-70 (API Publ. 4043)-- Atmospheric Haze: A Review, March 1970

Prepared by Beranek and Newman Inc. for the Coordinating Research Council, Inc. and the U.S. National Air Pollution Administration covers the characterization of haze; a general description of haze components; mechanisms of haze formation; distribution and dynamics of atmospheric aerosol; the quantitative analysis of turbulent diffusion; the optical properties of air pollutants; and instrumentation techniques for measuring hazes. Photographs, diagrams, graphs, tables, and 388 references.

CAPA-6-70 (API Publ. 4091)--Optical Studies of Automotive and Natural Hazes: Scattering from single particles (Final Report) February 1971

In a study by Science Spectrum Inc. for the Environmental Protection Agency and the Coordinating Research Council, Inc., the use of single particle light-scattering measurements to determine the origin of atmospheric hazes has been studied by measuring laboratory aerosols and field samples and by computer analysis of the light-scattering data. Analytical methods have been developed for determining the refractive index of such particles. An analysis of scattering curves for larger laboratory aerosol particles showed measurable differences in refractive index between a photochemical pine tree aerosol and an photochemical petroleum aerosol. Distinctive nonspherical and abosorbing particles were observed in both automotive exhaust and atmospheric samples. Diagram and graphs.

CAPA-7-70 (API Publ. 4027, 4028)--Final Report on Phase 1... Atmospheric Reaction Studies in the Los Angeles Basin -- 1 & 2) July 1969, June 1969

A report prepared for the Coordinating Research Council, Inc. and the National Air Pollution Control Administration by Scott Research Laboratories, Inc. Photographs, diagram, map, graphs, and tables.

CAPA-7-70 (API Publ. 4030,4031, 4032, 4033)--Final Report ... 1969 Atmospheric Reaction Studies in the Los Angeles Basin--1. Program Design and Methodology Data Summary and Discussion. 2. Commerce Ground Data. 3. El Monte Ground Data. 4. Airborne Data. Essa Data. February 1970

A report prepared for the Coordinating Research Council, Inc. and the National Air Pollution Control Administration by Scott Research Laboratories, Inc. Map, charts, graphs, and tables.

CAPA-7-70 (API Publ. 4029)-- Atmospheric Reaction Studies in the Los Angeles Basin... Phase II... Data Analysis and Methods Improvement. March 1970

A report prepared for the Coordinating Research Council, Inc. and the National Air Pollution Control Administration by Scott Research Laboratories, Inc. Graphs, tables, and 18 references.

CAPA-7-70 (API Publ. 4093,4094,4095)-- 1970 Atmospheric Reaction Studies in the New York City Area--1. Program design and methodology--- Data Summary and Discussion. 2. Bronx Ground Data (and) Tetroon/Helicopter Data. 3. Willowbrook Ground Data (and) Raritan Ground Data. 1971

In a study carried out by Scott Research Laboratories, Inc. sponsored jointly by the Air Pollution Control Office (now under the Environmental Protection Agency) and the Coordinating Research Council, Inc, trailer laboratories were set up in the Bronx, on Staten Island, and at Metuchen, N. J., to measure chemical and meteorological parameters and collect aerometric data. Maximum oxidant levels of 15-20 parts per hundred million (pphm) were recorded, but most readings were below 10 pphm. Although the oxidant levels did not approach those typically found in Los Angeles, the first step in photochemical reactions, the conversion of nitric oxide to nitrogen dioxide, was clearly evident almost every day, and the rate was at least as rapid as in Los Angeles. However, unlike Los Angeles, the conversion was not followed by a rapid ozone increase. Some possible explanations for these phenomena are discussed, and all the data collected are presented. Maps, tables, charts, and graphs.

CAPA-11-70 (API Publ. 4058)--Mechanisms for Removel of Carbon Monoxide from the Atmosphere, April 1970.

In a study carried out for the Public Health Service to identify sizable sinks for carbon monoxide in the atmosphere and the hydrosphere, promising carbon monoxide removal processes were first identified and the studied in the laboratory to evaluate the associated rates of carbon monoxide removal and thus to determine their significance with regard to the removal of carbon monoxide for the atmosphere. Three processes were considered: depletion of carbon monoxide in the stratosphere, oxidation of carbon monoxide by ozone in the troposphere, and oxidation of carbon monoxide in the dydrosphere. None of the processes considered could account singly for the total carbon monoxide sink required if the presently known rate of carbon monoxide emission is to be balanced by an equivalent removal rate. Rather, it appears that several processes contribute. Diagrams, graphs, tables, and 24 references.

CAPM-3 (API Publ. 4052)-- Experimental Human Exposure to Carbon Monoxide, August 1970.

This is a series of four articles done on the effects of carbon monoxide on humans published by the Medical College of Wisconsin. The four follow:

1. Exposure led to no untoward effects in sedentary males exposed to 100 parts per million (ppm) or less for eight hours. Exposures producing carboxyhemoglobin saturations greater than 15 per cent to 20 per cent resulted in delayed headaches, changes in the visual evoked response, and impairment of manual coordination. Diagram, graph, and tables.

2. Absorption and Elimination of Carbon Monoxide by Inactive Young Men.
Humans were exposed to carbon monoxide at concentrations of 1, 25, 50, 100, 200, 500, and 1000 ppm for periods of 0.5 to 24 hours and subsequently treated with 1.0 and 3.0 atm oxygen, and blood samples for carboxyhemoglobin were obtained during the exposures and for up to 23 hours into the postexposure periods. Of the several model equations tested against the absorption and excretion data, one theoretical equation accurately predicted the carboxyhemoglobin levels resulting from continuous and discontinuous exposures to unvarying concentrations and from continuous exposure to a steadily rising concentration of carbon monoxide. Graph, tables, and 11 references

3. Postexposure Relationship of Carbon Monoxide in Blood and Expired Air.
The postexposure relationship between venous blood carboxyhemoglobin (COHb) saturation and the concentration of carbon monoxide in breath is described by a quadratic equation derived from data obtained from 25 experimental human exposures to carbon monoxide. Alveolar breath analysis can be used for the accurate estimation of the postexposure COHb saturation in adult white males. Graph.

4. The effect of Carbon Monoxide on the Visual Evoked Response in Man and the Spontaneous Electroencephalogram.
In humans exposed to carbon monoxide at concentrations ranging

from 1 to 1000 ppm for 0.50 to 24 hours, carboxyhemoglobin levels greater than 20 per cent produced changes in the visual evoked response similar to those previously reported in animals. The amplitude of the 2-3-4 wave complex was increased and was accompanied by a negative-going shift in the 5a-6 waves. Carboxyhemoglobin levels approaching 33 per cent did not alter gross spontaneous electroencephalographic activity. Diagrams, graphs, table, and 12 references.

CAPM-4-68 (API Publ. 4096)--The Effects of Chronic Exposure to Low Levels of Carbon Monoxide on the Cardiovascular Systems of Dogs.

CAPM-7 (API Publ. 4059)--Development of a Research Program for the Evaluation of the Effects of NO_x and/or Oxidants upon Human Health in an Urban Environment ... A Final Report, April 1970.

In a study carried out by the Tulane University School of Medicine for the National Air Pollution Control Administration and the Coordinating Research Council, Inc., oxidants and oxides of nitrogen were continuously monitored in Los Angeles and Phoenix. The health effects of these pollutants can be demonstrated in occupational diseases produced by exposure to very high concentrations of the gases, as in Silo-Fillers' disease, caused by nitrogen dioxide. The study shows that a modern survey of respiratory health requires constant monitoring of the concentrations of the principal air pollutants and frequent and prolonged follow-up of a susceptible population living in a stable community. The survey must include a large population and must sample neighborhoods and communities with difference degrees of pollution to realize its aim. The instrumentation and procedures used in the study are described in detail. Table, diagram, and 80 references.

CAPM-8 (API Publ. 4060)-- Formulation of a Program for the Determination of the Range of Carboxyhemoglobin in the U.S., 1971

An outline of the variables, methods, and premises that should quide persons who might bid upon a contract to determine the range of carboxyhemoglobin in the U.S. covers the optimum sizes and types of populations to be covered, possible sample sources, and the obligations of the bidder with respect to epidemiologic design details, sampling methods, statistical treatment, etc. Diagrams,chart , tables, and 20 references.

ADDITIONAL API ENVIRONMENTAL REPORTS

Publ. 4026, High Molecular Weight Compounds in Vehicle Exhaust: State-of-the-Art, March 1967

A literature survey undertaken for the Coordinating Research Council, Inc., to summarize present knowledge concerning methods of measuring and analyzing high-molecular-weight compounds (e.g., polynuclear aromatics) found in automobile exhaust indicates need for information on the emission of high-molecular-weight compounds as a function of engine design and operating variables, fuel composition, etc.; for exploratory research to determine their role in initiating or altering the course of photochemical reactions in the atmosphere; for rapid methods of analysis of engine and fuel variables; for a test that gives a direct measure of potential carcinogenic action; and for standardization of available analytical methods. 23 references.

Publ. 4038, Cooperative Evaluation of Techniques for Measuring Hydrocarbons in Diesel Exhaust, February 1970.

In a cooperative experimental program carried out from 1967 to 1969 by the Air Pollution Research Advisory Committee (APRAC) of the Coordinating Research Council, Inc., the program group on the composition of diesel exhaust to evaluate techniques for measuring total hydrocarbons in diesel exhaust, had a small diesel engine shipped to 13 laboratories in succession, and each laboratory measured exhaust hydrocarbon concentrations by a method of its own choosing. The standard deviation of the measured concentrations was on the order of 50 per cent of the median values. Differences in sampling among the laboratories appeared to be a major source of the variation. Errors with currently used procedures are unacceptable for engineering measurements, and further work should be conducted at one laboratory with one multicylinder engine by all available techniques to locate and remedy as many of the sources of error as possible. Diagram, graphs, and tables.

Publ. 4040, Proceedings of the 1969 Joint Conference on Prevention and Control of Oil Spills, 1969

Publ. 4050, Procedures for Determining Exhaust Carboxyls As 2, 4-Dinitrophenylhydrazones (DNPH), June 1971

Determination by gas chromatographic analysis has been developed by the Bureau of Mines under contract with the Coordinating Research Council, Inc. Best results were obtained by passing the exhaust gas through a DNPH solution followed by filtration and extraction with pentane to recover soluble and insoluble dinitrophenylhydrazones prior to gas chromatography. A comparative evaluation of the chromatorgraphic method (GC-CHNPH) with the colorimetric (Col-DNPH) method and the gravimetric (Gr-DNPH) method showed that results by the Col-DNPH and the GC-DNPH methods are in good agreement; results by the Gr-DNPH method are considerably higher. The study also showed that exhaust analyses by the DNPH methods may be affected by the presence of nitrogen dioxide in the exhaust sample and of carbonyl contaminants in ambient air. The experimental procedures and results are described. Chromatogram, tables, and 12 references.

Publ. 4054, Oil Pollution Survey of the United States Atlantic Coast with Special References to Southeast Florida Coast Conditions, 1968

Publ. 4055, Proceedings "Industry Government Seminar on Oil Spill Treating Agents," 1970

Publ. 4073, Gas-Liquid Flow in Pipelines -- 2. Design Manual, October 1970

Following collection and evaluation of published correlations on gas-liquid flow, a practical design method is presented which combines reasonable accuracy with simplicity in application. Procedures presented are applicable to two-phase gas-liquid flow in gathering lines and pipelines. A knowledge of the type of gas-liquid flow in the pipeline is not required. From external conditions the properties of the gas and liquid are calculated at pipeline conditions. It is then possible to calculate a two-phase Reynolds number from the equations and to obtain the two-phase friction factor from the correlation. Methods for handling pressure loss due to elevation changes and acceleration also are given. The method has been successfully tested on field lines ranging from 6 in. through 16 in. Graphs.

AIR QUALITY MONOGRAPH SERIES

#69-1, Ambient Air Quality Standards for Particulates...
Review and Evaluation, February 1969

A review covers the physical and chemical properties of particles; undesirable effects of particulates in relation to the establishment of air quality standards; particulates and reduction in visibility; soiling or nuisance problems from particulates; and existing ambient-air quality standards for particulates. Graph, tables, and 33 references.

#69-2, Particulates: Air Quality Criteria Based on Health Effects, February 1969

A review covers the acute effects of the experimental inhalation of particulates, including physiological effects on the airways in terms of increased airway resistance, minor changes in compliance and disturbance of ventilation uniformity; the chronic effects of dusty air, including deposition of suspended matter (black pigment) in the lungs; and gas and particulate interaction, in which adsorption may modify the site of gas absorption in the respiratory system. Diagrams, table, and 30 references.

#69-3, On the Establishment of Air Quality Criteria, with Reference to the Effects of Atmospheric Fluorine on Vegetation, February 1969

A review covers the nature of atmospheric fluorine; problems in the evaluation of available data; possible criteria for different plants, including tomato, alfalfa, sorghum, corn, gladiolus, tree fruits (noncitrus and citrus) and conifers; distribution of atmospheric relevance of criteria to standards. Graphs and 66 references.

#69-4, Fluorosis of Livestock, February 1969

A review covers the factors affecting the occurrence of fluorosis, including species other than cattle; diagnosing fluorosis, including the clinical aspects, acute fluorine toxicosis, and chronic fluorosis; the effects of ingesting up to 93 parts per million (ppm) of fluorine for up to 7.5 year on the general condition of cattle, including the hair and skin, hoofs, soft tissues, blood, placental transfer, reproduction, and milk production; and methods of alleviating fluorine toxicity (e.g., with chemical food additives that act as inhibitors). Graphs, tables, photographs, and 30 references.

#69-5, Oxidants: Air Quality Criteria Based on Health Effects, February 1969

A review covers smog photochemistry; total oxidant (ozone), including environmental considerations and health effects; nitrogen oxides, including environmental considerations and health effects; hydrocarbons, formaldehyde, and polynuclear hydrocarbons, and criteria for the control of photochemical smog and oxidant concentrations. Graphs, tables, and 51 references.

#69-6, Photochemical Smog, February 1969

A review covers the nitrogen oxides, including atmospheric analyses, automatic monitoring in Los Angeles and Menlo Park, Calif. reactions with olefins, measuring total nitrogen compounds, and the phytotoxicity of nitrogen dioxide; oxidants, including the damage to plants, and adverse effects on citrus trees; organic pollutants (especially polynuclear aromatic hydrocarbons), including detectors, urban pollution, Los Angeles smog, and eye irritation; and various national and state air quality standards. Tables and 91 references.

#69-7, A Review of the Toxicology of Lead, February 1969

Covers the sources of environmental lead; body storage of lead; biochemical aspects of lead in the body; sources of lead over-exposure; pediatric plumbism; adult plumbish; lead alkyl intoxication; and air quality criteria. Tables and 287 references.

#69-8, Sulfur Dioxide and Plant Response, February 1969

A review covers symptoms, including acute injury, sulfate injury, and stomatal activity; environmental factors, including temperature, humidity, and soil moisture; physiological response, including the fate of sulfur dioxide, plant chemical compositions, effects on photosynthesis, and effects on plant growth; sulfuric acid mist; synergism; and permissible concnetration levels. 44 references.

#69-9, Air Quality Standards for Carbon Monoxide, February 1969

A review covers the existing levels of carbon monoxide and the health effects resulting from long-term, low concentration exposure to carbon monoxide alone or combined with other pollutants, as related to the establishment of air quality standards and methods of measuring atmospheric carbon monoxide concentrations. Graphs, tables, and 20 references.

#69-10, Facts and Opinions on the Role of Sulfur Dioxide in Causing Injury (to Human Health), February 1969

A review covers acute effects; chronic effects; mortality; morbidity; the effects of sulfur dioxide pollution on mortality; the effects of sulfur dioxide pollution on morbidity, including upper respiratory diseases, pneumonia, and bronchitis; and the absence of evidence that sulfur dioxide is a factor in health damage at the levels found in ambient air. Eighty-one references.

#69-11, Air Quality Standards for Lead, February 1969

A review covers the effects of exposure to lead on human health; lead levels in biological samples; atmospheric lead levels; and proposed air quality standards. Fifty-one references.

#70-12, Barium, October 1970

A survey prepared for API covers the geochemistry of barium in mineral deposits, in water, and in air; the presence of barium in marine organisms, in land plants and animals, and in mammals, especially man; human exposures to barium, with data on geographic variation, barium in the lungs, and barium accumulation in human tissues with age; atomic structure, biochemical functions, and pharmacology of barium; barium metabolism; the toxicity of barium salts, especially those used as pesticides and as smoke suppressants in diesel fuel; industrial exposures to barium; and air quality standards for barium. Tables and 20 references.

#70-13, Vanadium, October 1971

A review compiled for API covers the geosphere, in the atmosphere, and in the hydrosphere, vanadium and niobium in the biosphere; human exposures to vanadium and niobium, principally in food, and their accumulation with age; atomic structure, biochemical functions, and pharmacology; vanadium matabolism; toxicity of vanadium; the possibility that vanadium has a biological role in mammals essential for optimum function; and the tolerable limits of vanadium in air. Tables and 65 references.

#70-14, Nickel, October 1970

A review prepared for API covers the geochemistry of nickel; nickel in plants, animals, and man and its geographic variation; human exposures to nickel; atomic structure, biochemistry, and pharmacology of nickel; nickel metabolism, nickel toxicity, including dermatitis, respiratory diseases, and cancer; industrial exposures; and proposed air quality standards. Tables and 39 references.

#70-15, Chromium, October 1970

A review prepared for API covers the geochemistry of chromium, molybdenum, and tungsten; chromium and molybdenum in the air, including the sources and particle sizes; chromium and molybdenum in living things, including plants, animals, and humans, and changes with age; chromium in human lungs; human exposures to chromium and molybdenum in food; the atomic structure and biological functions of chromium; chromium metabolism; pharmacology and toxicity of chromium, especially the hexavalent form; industrial exposures of workers to chromium and the concomitant health effects; and air quality standards for chromium. Tables and 38 references.

#70-16, Cadmium, Zinc and Mercury, October 1970

A review prepared for API covers the geochemistry of zinc, cadmium, and mercury; sources and effects of zinc, cadmium, and mercury in the air; their effects on plants, marine organisms, mammals, especially man, and their concentrations in man as a function of age, cadmium and zinc in human lungs, human exposures to zinc, cadmium, and mercury; their atomic structures; their role in human metabolism; human requirements for zinc; the pharmacology and toxicity of all three metals; zinc, cadmium, and chronic diseases; and the air pollution aspects of zinc, cadmium, and mercury, including tolerable levels. Tables, graphs, and 70 references.

#70-17, Manganese, July 1971

A review prepared for API covers the geochemistry of manganese; manganese in living things, including plants, animals and the human lung and changes with age; human exposures to manganese in air, water and food; the atomic structure and biological function of manganese; its role in mammalian metabolism; the homeostasis and accumulation of manganese from the environment; pharmacology and toxicology of manganese; and air quality standards for manganese. Tables and 44 references.

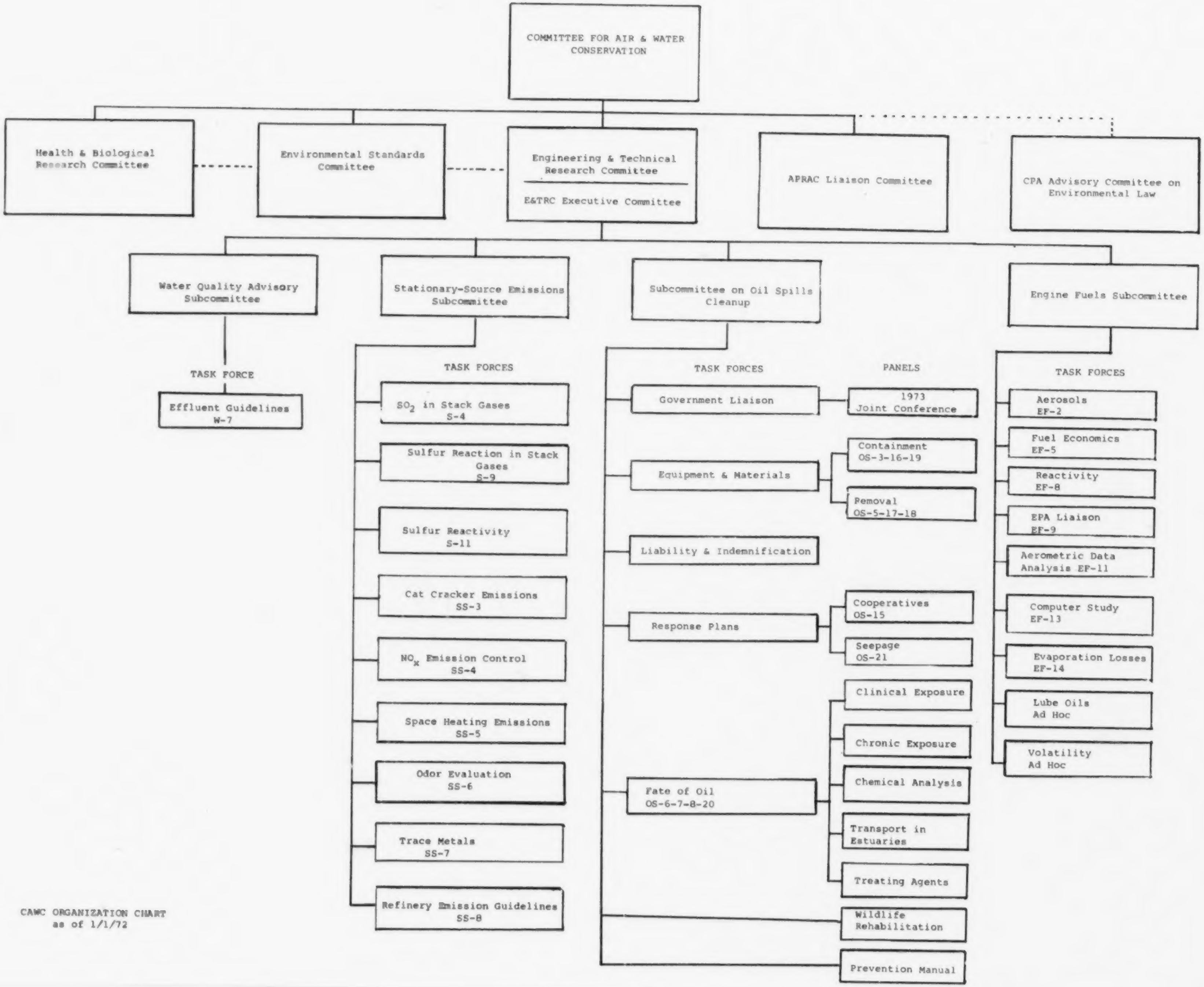
API MEDICAL RESEARCH REPORTS

#EA7101, The Long Term Effects of Sulfur Dioxide on Ciliary Activity in the Trachea, 1971

A research project sponsored by API and carried out at the University of North Carolina was developed to identify the pathogenetic steps in sulfur dioxide injury. The respiratory surface was selected as the most probable site of effect. Rats, hamsters and mice have been exposed to sulfur dioxide at 1 part per million (ppm), simultaneously with lmg/cu m of graphite or calcium sulfate dust for 12 hours daily, seven days per week, for up to 4 months. The ciliary activity, the microflora of the respiratory surfaces, the weight of the whole animal body, the weight of the major parenchymal organs, the hematocrit and the relative histology have been used as the indices of injury. All indicators concurred to minimize significant pathological effect on the respiratory surfaces; apparently something different and more complex than the effect of sulfur dioxide on the surface of the respiratory apparatus is responsible for the casualties from air pollution exposures. Graphs, diagrams, tables, and 11 references.

#EA7102, The Chronic Toxicity of Lead, April 1971

In an experimental study conducted by Hazelton Laboratories, Inc. for API to evaluate the effects of the ingestion of small amounts of lead acetate by laboratory animals (rats, dogs, monkeys, and rabbits) over a substantial part of their lifespan, 10 parts per million (ppm) (as lead) produced no detectable effects after 22 months; thus, 10 ppm lead in the diet is a "no-effect" level. Minimal effects were observed in some animals at 50 ppm, and some histologic changes (principally in the kidney), but no functional changes, were detected in rats fed 100 ppm and 1000 ppm. These amounts of lead administered to the animals are far above the usual intake by man. In addition to the common chronic toxicity tests, the program included studies on reproduction, teratology, behavior, carcinogenicity, and metabolism, as well as special enzyme and electron microscope studies.



CAWC ORGANIZATION CHART
as of 1/1/72

IV. ORGANIZATION

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(4)	Atlantic Richfield
(5)	British Petroleum
(6)	Chevron Standard of California
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(8)	Continental
(9)	Dupont
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(20)	Shell
(21)	Standard of Ohio
(22)	Sun
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(28)	Western Oil & Gas Association
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(32)	Champlin
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